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*ON THE PHYSICAL CONSTITUTION OF THE PLANET JUPITER.**

THE planet of Jupiter was one of the first objects to which the telescope of Galileo was directed, and the satellites of the planet were among the earliest discoveries made by that instrument. In 1630 the telescope had been constructed with sufficient power to show the great equatorial belt. Previous to the beginning of the eighteenth century the principal phenomena seen on the surface of Jupiter had been observed, and the time of rotation and position of the axis of the planet ascertained. Notwithstanding, however, the great mass of facts which have been collected from observations extending over a period of 200 years, yet up to the present time no theory of the physical condition of the surface has been advanced which has met with universal acceptance. In order that the subject may be more clearly understood it will be well to state briefly the salient features presented to the eye of the observer. The disk of Jupiter appears as an ellipse having axes in the ratio of 14 to 15, the longer axis lying in the direction of the planet's equator. The equatorial diameter is about 89,000 miles.

* Address of the chairman of Section A, Mathematics and Astronomy, and vice-president of the American Association for the Advancement of Science. Read at the Washington meeting, December 29, 1902.

Now as the axis of the planet is nearly perpendicular to the line of sight, we shall see objects in their true dimensions only near the middle of the disk and on the equator. In the revolution of the planet in its orbit, the equator, as seen from the earth, may be displaced 3.3 degrees. Therefore, all objects seen on the disk may apparently be shifted in latitude. At the equator the displacement may amount to 1.1″ of arc, or about one sixteenth of the polar diameter, while in higher latitudes it will be very much less, and at the latitude of 70 degrees the displacement will be only 0.28″ of arc.

During the past twenty-five years some astronomers, who have observed Jupiter for years, imagine that when the planet is turned with its axis three degrees toward the earth, one would be able to see to the pole and beyond. I may say that this is a mistake, for the reason that the displacement of three degrees would amount to only 0.03″ near the pole. It is very rare that any objects are seen beyond 40 degrees of Jovian latitude. The latitude of 70 degrees is only 1″ from the limb, and 80 degrees only 0.25″ from the limb of the planet. Hence objects, if they existed at high latitudes, would be practically invisible. During twenty-three years of observation I have never observed a separate marking beyond 42 degrees of Jovicentric latitude, or 5.7″ of arc from the limb, except on one night when a small white spot was seen in latitude 62 degrees, or within 2″ of the south limb of the planet. Usually a fine shading or discoloration of the disk is seen near the poles. The planet rotates on its axis in a little less than ten hours, and hence the shape and size of an object in passing across the disk will be materially modified by the effect of rotation. An object, when it is first brought into view on the disk by rotation, is infinitely short in length and, as it is brought farther on by rotation, the length is increased, and reaches its maximum when on the central meridian of the disk. In passing off, it of course goes through the same changes in apparent size. As the meridians on a globe are curved lines, objects in passing across the disk may apparently be displaced in longitude in regard to each other, due to the curvature of the meridian, viz., two spots lying in different latitudes might at one time be on a line parallel to the polar axis of the planet and, when brought on the middle of the disk, would lie in different longitudes. Some astronomers have been misled by phenomena of this kind, considering it to be a real motion of the object, when in fact it is simply displacement due to rotation.

In order then to know what phenomena are real and what are apparent, it is necessary to take into account the position of the earth with regard to Jupiter's equator, as well as the position of the object on the disk of the planet.

Jupiter is distant 5.2 times the distance of the earth from the sun, and at mean distance 1″ of arc amounts to 2,300 miles. Now owing to the great distance of the planet from the earth, the objects we see must have considerable size in order to be visible. I presume that the smallest object which has been observed for longitude or latitude is at least 2,000 miles in diameter. In the case of a line or streak one might be able to see with the aid of the modern telescope 0.1″ of arc in width, which on Jupiter would be 230 miles, but all the markings which have been observed are considerably greater in size than this minimum value. The ordinary spots we see on Jupiter, from which rotation time has been determined, have usually been upward of 3,000 miles in diameter, where the spot is circular or elliptical.

I began systematic observations on Jupiter in the year 1879, and these have been continued every year with the exception of the opposition of 1888 and a part of

1889, when the telescope was dismounted. I may say that, previous to this period, the observations of phenomena have usually been made by estimation. This was true with regard to the determination of longitude almost without exception, and very few positions in latitude have ever been determined with the micrometer. Amateur observers, who have no driving clock or micrometer, must necessarily rely on eye estimates for longitude and latitude, but when a telescope is equipped for micrometer work there is no better excuse for guessing than in the determination of the distance of a pair of double stars.

Sketches or drawings of the planet Jupiter are of very little value in the absence of other data. It is not unusual to find the latitude of conspicuous markings eight or ten degrees in error, and longitude a corresponding amount. At the beginning of my observations on Jupiter I decided to fix the size and position of all objects seen on the disk by micrometrical measurement. By such a system of procedure positive facts will be established, which in time may enable us correctly to interpret the complicated phenomena observed.

During the past twenty-five years the so-called canals and double canals on Mars have been the subject of much discussion. I believe if their position were fixed by micrometrical measurements, we should soon be able to decide what is real and what is imaginary.

In order to use the micrometer for measurements on a planet, it is necessary to know the size of the disk. Jupiter has been measured by many astronomers, both with the micrometer and with the heliometer, but the measurements made differ considerably, due to two causes. First, irradiation, which depends on the size of the telescope, or rather on the magnifying power employed. Second, the increased size of the image, due to the condition of the atmosphere. In the use of the heliometer the true irradiation may be eliminated, but not the increased size of the disk due to definition. In any case the measured size of the disk depends directly on the magnifying power employed.

In 1880 I made a series of measures of the polar and equatorial diameter of the planet with powers of 390 and 638, and in 1897 a series of measurements with powers of 390 and 925. In all cases, whatever the condition of the seeing, the lower power gave the larger diameter. From the measures made on six nights in 1897, when the seeing was good enough to be able to use a power of 925, the difference for the two powers employed was: polar, $+0.27''$; equatorial, $+0.31''$. In 1880 for ordinary seeing the difference for the two powers employed amounted to $1''$. In order, therefore, to have some standard of size it would be necessary to decide upon the magnifying power employed with which the measures were made. Because of this apparent change in the size of the disk due to definition, to locate with precision any object on the surface of the disk, or a satellite off the disk, it is necessary to refer the object to both limbs of the planet at the time of observation. If the object is referred to only one limb, under unfavorable atmospheric conditions an error of $1''$ of arc would be easily possible, but if it is referred to both limbs, then the effect of the irradiation, or enlargement of the disk, is almost wholly eliminated. In the reduction of my micrometrical work on Jupiter I have used the values $18.33''$ and $19.48''$ for the semi-axes of the planet at mean distance.

These values for the size of the disk were found from a great many differential measures made in 1880–1 with a power of 390, and are somewhat larger than those given by the heliometer, owing to

irradiation, but they will probably better satisfy micrometer work.

The observations for longitude, latitude and magnitude of objects on the planet Jupiter have all been made with the parallel-wire micrometer, preferably near the central meridian, but no rigid rule is followed in this respect. The longitude and latitude are usually determined whenever the spot or marking is wholly on the disk and distinctly visible.

The longitudes are measured by ascertaining the distance of the apparent center of the object from the limb of the planet, according to the method I pointed out some years ago. A determination of longitude or latitude generally consists of three bisections of the object and each limb of the planet. In the case of longitude, one half of the difference of the distances at the mean of the times is the distance of the apparent center of the object from the central meridian on the visible disk. This method of determining longitudes has been found to be greatly superior, in point of accuracy, to the method of transits, as well as a great saving of time.

The error in measurement of objects on a luminous disk is about twice as great as that from the measurement of double stars of equal distance. The ordinary error for location of objects in latitude or longitude on the disk of Jupiter may be placed at about 0.25″ arc.

Twenty-five years ago it was almost the general opinion among astronomers that the phenomena seen on the planet Jupiter were transitory in their nature; that there was no permanency in the spots and markings, but that the aspect of the planet changed from day to day, and even at less intervals of time. Perhaps we shall get a better idea of what was known about the subject by quoting from Grant's 'History of Physical Astronomy':

"Although generally there appear only three belts upon the disk of the planet, sometimes a greater variety is perceptible. Sometimes only one belt is visible. This is always the principal belt situated on the northern side of the planet's equator. On the other hand, its whole surface has occasionally been seen covered with belts. On the 18th of January, 1790, Sir William Herschel, having observed the planet with his forty-foot reflector, perceived two very dark belts dividing an equatorial zone of a yellowish color, and on each side of them were dark and bright bands alternating and continuous almost to the poles. A similar appearance was once noticed by Messier. These phenomena sometimes undergo very rapid transformations, affording thereby a strong proof that they owe their origin to the fluctuating movements of an elastic fluid enveloping the body of the planet. On the 13th of December, 1690, Cassini perceived five belts on the planet, two in the northern hemisphere and three in the southern hemisphere. An hour afterwards there appeared only two belts nearer the center and a feeble trace of the northern belt. The same astronomer frequently witnessed the formation of new belts on the planet in the course of one or two hours. The dark spots on the disk of the planet also afforded unequivocal indications of the existence of an atmosphere, for it is impossible to reconcile their variable velocity with the supposition of their being permanent spots adhering to the surface of the planet. Cassini found from his observations that the spots near the equator of the planet revolved with greater velocity than those more distant from it. Sir William Herschel found that the velocity sometimes underwent a sensible change in the course of a few days. He supposed the spots to be large congeries of cloud suspended in the atmosphere of the planet, and he ascribes

their movements to the prevalence of winds on its surface which blow periodically in the same direction."

Lardner, in his 'Astronomy,' says: 'In a month or two the whole aspect of the disk may be changed.'

In my annual report to the Chicago Astronomical Society for the year 1881, I stated that the phenomenon seen on the surface of Jupiter was of a more permanent character than had hitherto been believed to be the case.

In 1878 a large and conspicuous object known as the Great Red Spot was seen on the disk of Jupiter. It appears that this object was first noted on June 2, by Lohse, of Potsdam, but in looking up previous records, we find a spot seen in the same locality by the ancient astronomers. In the years 1664–6, a great red spot was observed by Hook and Cassini. It was situated one third of the semi-diameter of the planet south of the equator in latitude 6″. Its diameter was about one tenth the diameter of Jupiter, or about 8,000 miles. This spot appeared and vanished eight times between the years 1665 and 1708. From 1708 to 1713 it was invisible; the longest time of its continuing to be visible was three years, and the longest period of its disappearing was five years. Since its appearance in 1878 it has been visible with large telescopes during the whole period, but at times so faint that, except for the indentation in the equatorial belt, the spot, perhaps, would have been lost to astronomers, as it was formerly when they had smaller instruments.

The great red spot is 11.61″ or 37.2 degrees in length, and 3.87″ in breadth, or about 27,000 miles long, 9,000 miles broad, elliptical in outline, and, if we suppose the depth of the spot equal to its width, its volume would be about three times that of the earth. This object, which seems to have great permanency, is not stationary in either longitude or latitude.

It was visible in 1869 and 1870, when it was observed by Gledhill on four nights from November 14 to January 25, and on one night by Mayer. The data for ascertaining the rotation period have been derived from the drawings made, and necessarily are approximate.

The rotation period was $9^h\ 55^m\ 25.8^s$, or about eight seconds less than it was in 1879. From the observations made in 1878 I derived a rotation period of $9^h\ 55^m\ 33.7^s$. Since the rotation period had been increasing for twenty years, the observations in 1869 are of value in tracing the motions of this object.

I may add that Mr. W. F. Denning, who has compiled the observations of what is presumed to be the red spots from 1831 to 1899, finds a rotation period of $9^h\ 55^m\ 34^s$ between 1869 and 1878, by assuming the number of rotations between consecutive observations. But where the interval is five years and upwards this is a very unsafe method of procedure, as will be perceived from the motions which have been studied during the last twenty-three years.

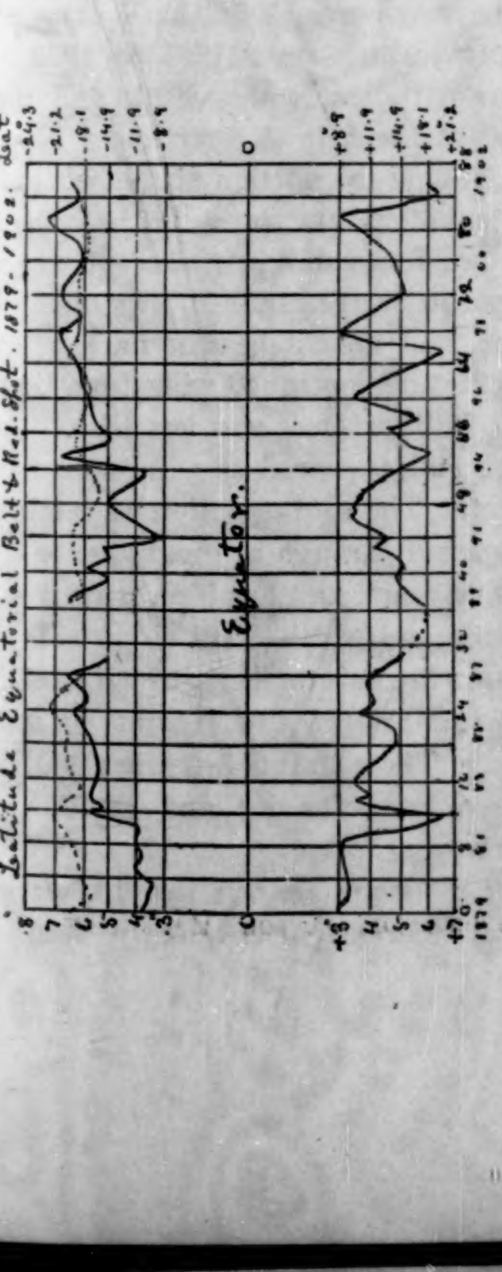
From the measures which I have made every year I have determined the rotation period for the red spot from 1879 up to the present time, and with the minimum value in 1879 of $9^h\ 55^m\ 34^s$. The diagram shows the rotation period at any point between 1879 and the present time. The vertical lines are intervals of 400 days, one day more than the synodic period of the planet. The horizontal lines represent seconds of arc, so that the rotation period at any point will be shown on the curve, the seconds being at the left hand of the diagram, and the time at the bottom of the diagram. The rotations for this curve were computed for intervals of 400 days by using at each epoch about twelve normal places, and the

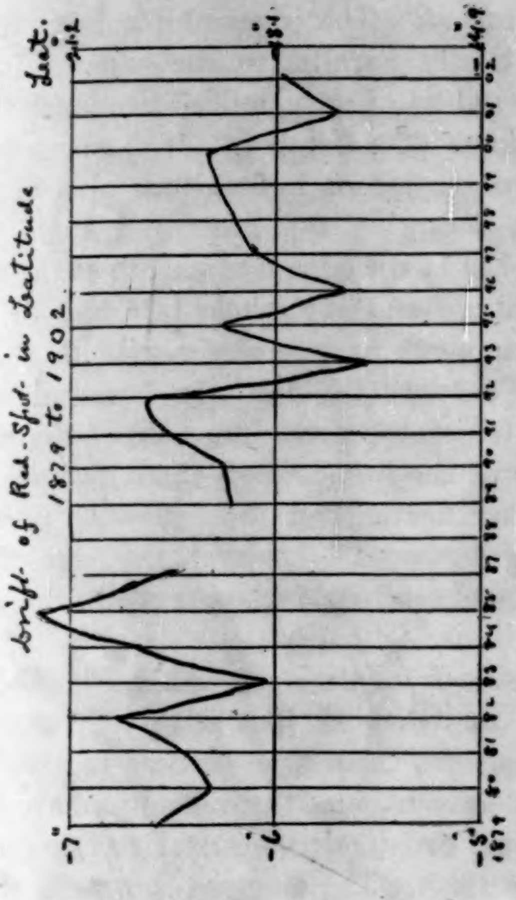
probable error on the rotation period, as determined in this way, varies between $\pm$ 0.02 sec. and $\pm$ 0.07 sec. The curve is perfectly smooth for the first six years, showing that the motion of the spot was very regular. Since that period the curve is not absolutely smooth, which may be due to the faintness of the object, and the shifting of the center from which the measurements were made, when the measures were referred to the bay in the equatorial belt. My measures, when the spot was very indistinct, have been referred to the center of the bay, and that may account for the small irregularities in the curve during the later years. From the diagram it is seen that the rotation period of the planet reached its maximum between 1898 and 1899, being 41.7 seconds. Previous to 1898 the spot had an apparent retrograde motion on the disk of the planet, and since that time the spot apparently has come to rest, and now has a direct drift around the planet. The rotation period for the last 400-day interval is 39.75 seconds, but the actual period at the present time is about three seconds less than it was in 1898. From the inspection of this curve, taken in connection with the rotation period which I found for 1870, it would seem to require a long cycle to make the rotation period the same as it was in 1879. The dotted curve indicates the 'mean' rotation period at any instant, counting from September 25, 1879. The 'mean' period for the interval 1879 to 1902 is $9^h\,55^m\,39.93^s$.

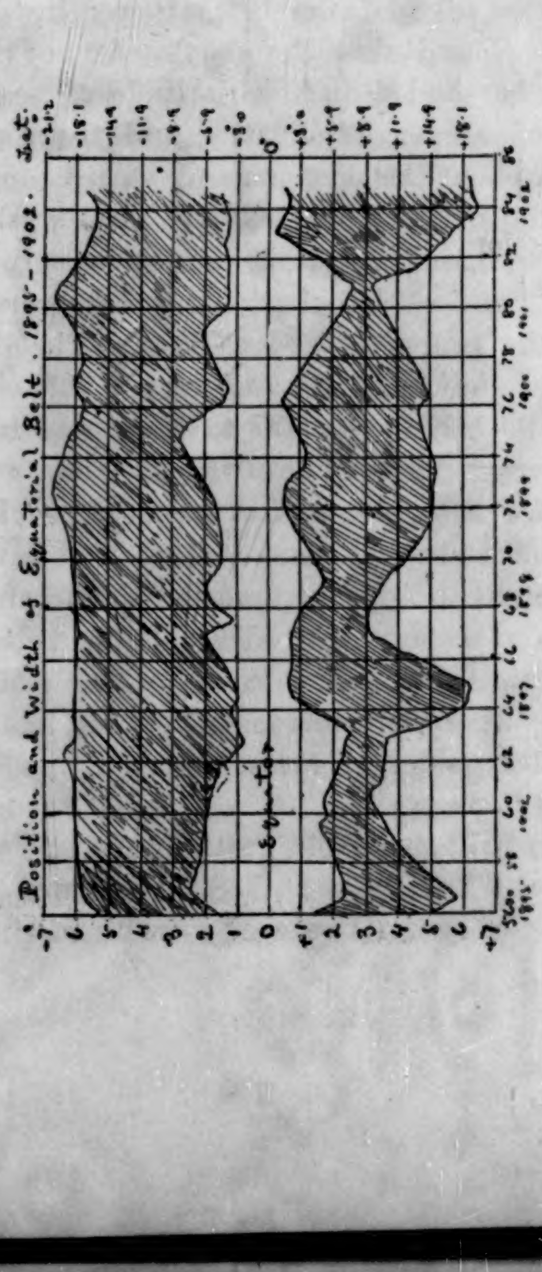
In 1880, when the red spot was most conspicuous, it was seen, when brought on the disk by rotation, at 87 degrees of longitude, or $2^h\,35^m$ in time from the central meridian, when its length was only second of arc. When the spot is wholly on the disk its longitude is 71.4 degrees and the apparent length 3.7″. It is possible that the rotation period may be connected with its visibility, viz., when the spot comes back to the same rotation period it had in 1879 it may become more conspicuous and reddish in color. This object has drifted in longitude about three and one fourth times around the planet since 1879, assuming the rotation period at that time to be the true rotation period of the planet. It seems to me, however, more probable that the time of rotation of the planet is longer than any period hitherto determined, in which case all objects would drift in the same direction. The object also has a motion in latitude, and the total displacement in twenty-three years has been 1.7″, or about 4,000 miles drift in latitude. The rate of drift in longitude and the visibility may possibly be due to the greater or less submergence of the spot in the material which composes the surface of the planet.

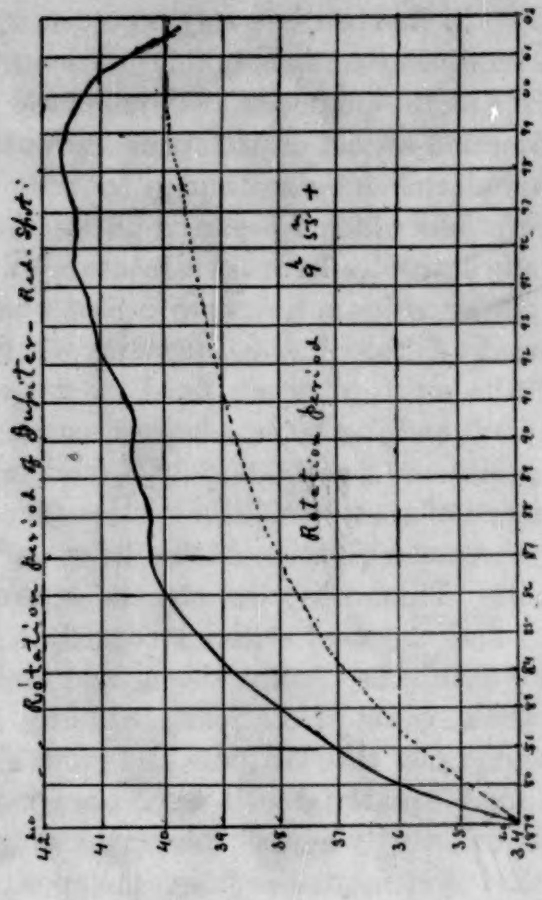
The diagram shows the mean latitude of the red spot at each opposition corrected for the elevation of the earth above Jupiter's equator. It seems that during these twenty-three years the spot has approached nearly 1″ nearer the equator than it was in 1879. The short time scale, the vertical lines being intervals of 400 days, makes the displacement appear more abrupt than it really is. The Jovicentric latitude is given on the right hand of the diagram. At the present time this is about eighteen degrees. We might add that this displacement in latitude of the red spot is very much less than the displacement of the great equatorial belt.

The most conspicuous marking on the surface of the planet is the great equatorial belt, which is always visible. This belt may appear as one belt, but usually is composed of two portions lying on either side of the equator of the planet. In 1880 it was practically one belt extending without break for a short time across the surface of the equator. From the study of the


Latitude Equatorial Belt & Red Spot. 1879-1902.
Lat.
Equator.


Drift of Red-Spot in Latitude
1879 to 1902.
Lat.


Position and width of Equatorial Belt. 1895-1902.
Lat.
Equator


Rotation period of Jupiter - Red-Spot.
Rotation period 9h 55m +

changes in this belt one may arrive at some idea regarding motions taking place on the surface of the planet. The systematic determination of motion in latitude has never been undertaken by any one previous to the observations which I began in 1879. Occasionally latitudes have been measured during one opposition. Arago, in 'Astronomé Populaire,' raised the question whether the belts on Jupiter are fixed in size and position, and he gives some measures of the positions from 1811 to 1837, and takes the mean of these various measures for getting the mean position of the belts on the planet. These observations are approximate, and are used without regard to the position of the earth above and below Jupiter's equator. From 1879 to the present time the latitude and width of the great equatorial belt have been measured on nearly every observing night, so that we may ascertain the position of the edge of the belt at any instant. It is found that the north edge of the belt has had a drift in latitude of nearly 4″ of arc or 12 degrees, and the south edge about the same amount. The changes in the drift of the belt are usually slow and gradual, but it is possible sometimes that considerable change may be observed in the course of a few days. The diagram indicates the position of the edge of the belt from 1879 to 1902, and it is of very great interest in showing at a glance the changes that have taken place in latitude. From the study of this diagram it appears that the disturbances take place on both edges of the belt at practically the same time. The matter composing the belts generally has a motion on both sides of the equator in opposite directions.

In 1879 the whole width of the belt was about 7″ of arc. In 1882 it widened out and has at times reached a width of about 13″ of arc. The edges of the belt remain practically parallel to the equator in all longitudes. I have noticed two marked exceptions. On October 3, 1882, there was a curved projection in longitude plus 30 minutes, following the great red spot. On October 14 the edge was smooth at the same longitude and the whole belt had drifted so far north as to coalesce with B_3. Also on February 24, 1897, in longitude plus five hours, the preceding half of the north edge of the belt drifted about two seconds farther north than the following portion. On February 27, however, the edge of the belt was comparatively smooth in the same longitude.

Aside from the drift of the edges of the belt in latitude, the belt itself changes dimensions from time to time to a considerable extent, and these changes have been studied from micrometrical measurements since 1895. The diagram shows the width of the two portions of the equatorial belt at any instant from 1895 to 1902. The diagram indicates the width and not the shape of the belt at any time. Now it is seen, taking the portion of the belt north of the equator, at times it becomes very narrow; for instance in 1896 it was about 1″ arc in width, 1897 it was about 5″ in width, and then it became narrower again in 1898, and continued wide from that time until 1901, when it was less than 1″ arc in width and appeared as a faint line on the planet. The south portion of the belt has not passed through so great change during the five years, and has been more steady in latitude and width. On either side of the equator are fainter belts which usually extend to 40 degrees of latitude as separate belts. These faint belts are subject to change, in both size and position, from year to year.

On the belts and on the surface of the planet there are frequently seen small

spots, sometimes white and sometimes black, viz., 2,000 miles or more in diameter, and from the observations of these spots we have determined the rotation period of the planet for different parts of the surface. The spots, which appear near the north margin of the equatorial belt nearly every opposition and are sometimes permanent for two or three years, and have a slight motion in latitude, only a fraction of 1″ of arc, whereas the belt may move 3″ or more in latitude in one year. It seems to me that this fact has an important bearing as to location of the objects, viz., the belt and the spots. I infer from the slight displacement of the spots that they lie at a lower level in the Jovian surface than the equatorial belt, and for the same reason the great red spot lies at a lower level.

The transits of the satellites of Jupiter offer phenomena which have a direct bearing on the constitution of the planet. The satellites at times cross all parts of the disk in transit. For a normal transit the satellite disappears at some distance from the disk after ingress and reappears at a similar distance before egress. From this fact it is concluded that the center of the disk of Jupiter has the same reflecting power as the satellites. With the 18½″ refractor I have ascertained that a satellite can be followed for a distance of 10″ of arc from the limb or nearly one quarter the diameter of the disk before it disappears in transit. However, when the transit occurs within 10″ of the north or south limbs, the satellite can be seen during the entire transit across the disk. Now since the satellite is not supposed to be hot enough to give light, we conclude there is not sufficient heat in the planet to produce light. The observation of the eclipse of the satellite also shows that it has no inherent light of its own.

Aside from the period of 9^h 55^m, some spots and markings give a shorter period of 9^h 50^m, indicating that these objects have a motion of about 250 miles an hour in the direction of the planet's rotation, assuming that the true rotation period is 9^h 55^m. For mechanical reasons the spots which give this shorter period must necessarily be located above the spots which give the longer period of 9^h 55^m. From 1879 to 1885 two white spots in latitude 6 degrees south were observed every year, giving a rotation period of 9^h 50^m plus. The white spots, during the last twenty years, which give this short period, have been observed between the latitudes plus 11 and minus 8, and also in one year, in 1891, black spots which gave a short period were observed in latitude 20 degrees north. The spots and markings which give the long period of 9^h 55^m have been observed in latitudes between 37 degrees north and 38 degrees south and within 12 degrees of the equator.

The equatorial belt sometimes approaches the equator very closely, and its rotation for some years has been the same as that of the great red spot, for the spot and the belt have, as we know, maintained the same position toward each other. Hence we find the longer rotation period of 9^h 55^m in precisely the same latitude as the shorter period. On examining the table of rotations there does not seem to be any connection between latitude and rotation period, as has often been alleged. The longest period which I observed, covering an interval of 156 days, is 9^h 56^m 0.4^s, which was in latitude 26 degrees north.

Mr. A. S. Williams has written some articles on the rotation of the surface of Jupiter in which he finds zones of constant currents. These speculations are not sound, for the reason that in the same latitude we find different rotation periods for the same instant of time, and, as I have said before,

there is no law connecting rotation period with the latitude, except we find this period of 9^h 50^m more commonly between the limits of -8 and $+11$ degrees, whereas the longer period is distributed indiscriminately over the surface of the whole planet as far as 38 degrees latitude.

The question has sometimes been raised as to whether the phenomena on Jupiter were periodic. The inclination of Jupiter's equator to its orbit being only three degrees, any periodicity due to the revolution of Jupiter around the sun should recur at intervals of about twelve years, but from the motions which I have shown for the displacement of the belts in latitude there does not seem to be any regularity in the period. I presume any periodicity is of the same nature as we have in the meteorology of the earth. We have, of course, a sequence in the seasons and a sequence in weather conditions, but our sequence in weather conditions does not follow any regularity, and if changes on Jupiter are due to meteorological causes, we should not expect to find any definite period.

The application of photography to astronomical observations has been of great value in various directions, but up to the present time it has been of no benefit in the study of planetary details. Photographs of the planet Jupiter have been made since 1880 at different times, but they only show the simple outline and some of the conspicuous markings. The scale of photograph is so small that it cannot be used with any degree of success for determining position on the disk. There is no question, however, that if we are ever able, by increasing the sensitiveness of our plate, to make an enlarged photograph of Jupiter or Mars such as is seen through the telescope with the eye, it would be a great advance, and it would enable us to decide very many questions, which are now impossible owing to the limited time that we are able to study the object under consideration, due to the rapid motion of the planet on its axis. The phenomena seen on the planet depend in a great measure on the size of the telescope and the magnifying power employed. In my work on Jupiter I have habitually used a power of 390, which is adapted to most conditions for seeing and will show minute detail. With the same telescope, using a power of 190, the appearance of the disk is quite different, and minute detail cannot be seen with distinctness. The observers who have small telescopes of five or six inches in aperture and use a comparatively low power do not see the phenomena as they would be shown by larger telescopes and high power. Hence in any question of disagreement, observation with the small telescope should have very little weight. The principle is precisely the same as in the observation of double stars. While a pair of close or unequal double stars may be easy objects for 18½″ object glass, they are entirely beyond the range of a 6″ object glass.

A misinterpretation of phenomena has given rise to very erroneous notions regarding the changes which take place on the surface of the planet. When we look at the planet Jupiter, we see only about one fifth of the surface in longitude distinctly at any one time, and hence in the course of two hours we should have an entirely new set of features under view of the eye of the observer. The faint belts north and south of the equator sometimes only extend over a portion of the circumference of the planet, and in such case one might see a greater or less number of belts after the interval of two hours or more, as has been stated by Cassini and others.

My observations during the past twenty-

three years have established the following facts:

1. The equatorial belt changes in both size and position to a considerable extent, but these changes are usually slow and gradual. Occasionally, however, a marked change may be observed in the features of the belt in the course of a number of days.

2. The fainter belts also are displaced in latitude and in the amount of material of which they are composed. The visibility of the fainter markings and spots depends in a considerable measure on the distance of the planet from the earth. When the planet is at more than mean distance, the so-called polar belts are very faint and sometimes invisible, even with a large telescope, and are not brought into view until the planet approaches toward opposition. This fact I noticed particularly in the early years of my observation on Jupiter, when the observations were made as near the sun as possible.

3. The egg-shaped white spots, which appear in this form from perspective, as they are probably nearly circular, are found both north and south of the equator and are very permanent in latitude. They are usually from one to two seconds of arc in diameter. These spots are not fixed with regard to each other, even when they are located in the same latitude.

4. Aside from the white spots, there are dark spots of similar size, sometimes on the faint belts and sometimes entirely disconnected from the belt. The dark matter is not as stable as the egg-shaped white spots, and probably lies at the same level as the equatorial belt.

5. Near the equator are found white spots, usually of a larger size and more irregular in shape, which give rise to the period of $9^h\ 50^m$.

The mean density of the planet Jupiter is 1.37 times that of water. The spheroidal figure of the planet indicates that the density increases as we proceed from the surface to the center. In the case of the earth the density at the surface is about one third the mean density, and assuming the same rule for Jupiter, its surface density would be 0.4 to 0.5 that of water. The liquefaction of air and gases during recent years enables us to imagine a medium which would have the density corresponding to that of the surface of the planet. The older astronomers, of course, had no knowledge of any substance between atmosphere and liquid, and hence, in forming their theories of the motions on the surface of the planet, the theory was necessarily atmospheric, but there is now no excuse for maintaining an atmospheric theory which will not account for the phenomena observed.

A probable theory of the constitution of the planet should in some degree satisfy all the phenomena observed. No one can draw legitimate conclusions from casual observations. On the surface of Jupiter we find the following objects: (1) The great red spot, which is the most stable of all objects seen on the disk of the planet. During the period that its size has been measured with the micrometer one cannot say with certainty that there has been any change in its size or shape from 1879 to 1902. It is now conceded by astronomers that the object is identical with the spot observed by early astronomers. Such being the case, it would seem to be absurd to say that anything in the nature of a cloud should persist in the same form for more than 200 years. Its spheroidal shape in connection with its stability would seem to show that it has volume and mass. Its motion in latitude, as we have already seen, is much less than for the equatorial belt. The matter of which it is composed is in a different condition to that of the belt. In 1880 I had the good fortune to notice the transit of a satel-

lite over the red spot. The satellite, which was invisible during transit, when projected on the spot appeared as bright as when off the disk. On the contrary, when satellites transit the belt they are invisible. (2) Egg-shaped white spots from 2,000 to 5,000 miles in diameter. These spots I have found in north latitude 13 to 37 degrees and in south latitude from 18 to 27 degrees. These objects do not look like clouds, and so far as we know they do not change their shape during the six months while under observation. They are also very stable in latitude and give a rotation period of $9^h\ 55^m +$. (3) Small black spots seen on the belts or entirely separate. These objects give a rotation period of $9^h\ 55^m +$, but on one occasion in latitude 20 degrees north I found a short period. (4) The dark matter forming the system of belts including the equatorial belt and the so-called polar belts, which also give a rotation period of $9^h\ 55^m$. (5) The white spots which give a rotation period of $9^h\ 50^m$.

It seems to be the opinion of most writers on Jovian phenomena that the planet is yet at a high temperature, but not self-luminous. The high temperature is favorable for the explanation of some of the phenomena observed. I have long held the opinion that a simple atmospheric theory was not sufficient. The greater luminosity of the center of the disk indicates absorption of light, probably due to an extensive atmosphere. The white spots which give a rotation period of $9^h\ 50^m$ are of different form and size from the egg-shaped spots which give the period of $9^h\ 55^m +$. The short period spots are greater in size and irregular in shape, sometimes appearing simply as a rift in the equatorial belt. Having these facts before us, we can formulate a theory which will fairly well satisfy all classes of phenomena.

I assume that the visible boundary of Jupiter has a density of about one half that of water. This medium is in the nature of a liquid; in it are located the great red spot and the egg-shaped white spots. In such a medium all motions in longitude and latitude would be slow and gradual, and the shape and size of the object would have great permanency. The equatorial belt and the so-called polar belts may be located on the surface or at a higher level than the red spot. In the middle latitude within twenty degrees of the equator the higher atmosphere carries a layer of dark matter in the direction of the rotation of the planet at a velocity of about 250 miles per hour, making a complete circuit around the planet in 44 days. In this envelope are formed the openings which we call white spots and, by unequal distribution, black spots. The great bay in the south edge of the equatorial belt may be accounted for by assuming that the great red spot is at a lower temperature than the medium in which it floats, and by its lower temperature condensing a portion of the vapor composing the belt. In 1882, when the edge of the belt drifted south, it did not come in contact with the spot at any point, although it advanced at times beyond the center. In 1883 I stated that the spot seemed to have a repelling influence on the belt. During the past twenty years, when the belt and the spot were in proximity a depression was formed in the belt directly opposite, which was of the same form as the contour of the spot. The belts may be assumed to be some sort of vapor of considerable density. The cloudlike matter, which in the equatorial regions is moving over the surface at the rate of 250 miles per hour would account for the minor changes on the surface of the equatorial belt. I think the theory I have given offers a more plausible explanation of the various phenomena observed than the off-

hand statement that we see simply clouds floating in the atmosphere of the planet.

G. W. HOUGH.

THE ORIGIN OF TERRESTRIAL PLANTS.*

I SHOULD like to invite your attention for a little while to some of the factors that apparently have been operative in determining the changes which plant structures have undergone in the course of the development of the vegetable kingdom. While some of these are perfectly obvious, others are by no means so evident, and, as might be expected, there is not perfect agreement among botanists as to the relative importance of some of these factors, nor indeed of their efficiency at all.

I shall not attempt here to go into any extended discussion of the remarkable results obtained by Professor De Vries in his recent studies upon variation in plants. These are too important, however, to be dismissed without some mention. The conclusion reached by Professor De Vries is that, in addition to the variation within the limits of species, there may be sudden variations, or 'mutations,' which, so to speak, overstep the limits of the species, and thus inaugurate new species. While the results obtained, especially in the case of *Œnothera Lamarckiana*, are certainly most striking, more data are necessary before we can accept without reserve the conclusions reached. It is certain that marked changes—'sports,' as the gardeners term them—often appear without any explainable cause, and it is equally difficult to understand, what for want of a better term, we can only term 'tendencies' to develop in special directions. Thus the specialization of the sexual reproductive cells, which has evidently taken place quite independently in several unrelated lines; the development of heterospory, and probably of the seed-habit in different groups independently, are hard to explain without assuming an innate tendency to vary in a determined direction.

It is not, however, with these exceedingly difficult and often obscure problems that we shall concern ourselves here, but rather with those changes in plant structures which are referable to more or less evident response to known conditions.

Speaking in broad terms, I think we can reduce the determining factors to three categories, leaving aside the inherent tendencies to variation. These three sets of factors are: (1) those relating to the food supply, (2) the relation to water and (3) those concerned with reproduction.

It is hardly necessary to say that there is no fundamental distinction between plants and animals. At the bottom of the scale of organic life are many forms, especially those belonging to the group of Flagellata, which are intermediate between the strictly animal and vegetable organisms.

We may safely assume that the primitive organisms were motile, perhaps resembling some of the existing flagellates. Of the latter some are destitute of pigment and approach the lower Protozoa; others are provided with chromatophores containing chlorophyll and resemble the lower plants. It is highly probable that the forms with chromatophores are able to assimilate carbon dioxide, as the typical plants do, and may be denominated 'holophytic.' The forms without chlorophyll are probably, like animals, dependent upon organic food for their existence.

If we compare the holophytic flagellates with those forms which have no chlorophyll, a significant difference may be noted, which is evidently associated with

* Address of the chairman of Section G, Botany, and vice-president of the American Association for the Advancement of Science. Read at the Washington meeting, December 29, 1902.

their nutrition. The holophytic forms are noticeably less motile than the others. Thus *Euglena,* one of the commonest green flagellates, becomes encysted before division takes place. The resting cell has a firm membrane about it, and closely resembles a typical plant cell. The forms without chromatophores, however, *e. g., Scytomonas,* may divide longitudinally in the active condition. This difference in motility between the forms with and without chromatophores seems to be the first hint of the differentiation of the characteristically motile animals and immobile plants.

One group of plants (Volvocaceæ) evidently allied to the Flagellata, and sometimes even included with them, like animals, show active locomotion during their vegetative existence. Aside from these, and the Peridineæ, which may be remotely related to them, locomotion is exhibited only by such reproductive cells as zoospores and spermatozoids. The frequent reversion to the motile condition found in the reproductive cells suggests the probability that these have been derived from similar ancestral forms.

The loss of motility in typical vegetable cells is associated with the formation of a firm membrane, usually of cellulose, about the cell. This precludes all movement of the cell, except in those cases where openings are present, through which extensions of the protoplasm, usually in the form of cilia, protrude.

The power of free locomotion was probably a character of the primitive vegetable cell, but with the development of the holophytic habit, this power has been lost by the vegetative cell of most plants. The loss of locomotion in plants may probably be connected with the development of the power to assimilate carbon dioxide, the main source of food. As the CO_2 in the air, or dissolved in water, is constantly being received, it is not necessary for the plant to move from one place to another in search of food, and we find plants becoming more and more stable. Where animals are so placed that their food supply is abundantly received, they may assume an immobile plant-like habit. This is especially marked in many marine animals, such as corals, hydroids, sponges, ascidians and such molluscs as oysters. The old name 'zoophyte' applied to corals and similar animals was not in all respects a misnomer. These rooted marine animals exhibit another resemblance to plants in the development of free swimming larvæ, analogous to the active zoospores produced by so many algæ. In both instances it is safe to assume that the motile stage is older than the fixed condition.

Lack of time forbids our consideration in detail of the very important, but by no means clearly understood, problems dealing with the evolution of sex in the vegetable kingdom. Thus the reason why the development of distinct sexual cells has taken place in an almost identical manner in several widely separated groups of plants is hard to explain. The sexual cells, or gametes, have beyond question been derived from non-sexual ones. Thus in several groups of algæ; *e. g.,* Volvocaceæ, Confervoideæ and Phæophyceæ, there still exists an almost perfect series of forms leading from the non-sexual zoospores to perfectly differentiated male and female gametes. The formation of sexual or non-sexual reproductive elements is, in many cases at least, largely dependent upon the conditions under which the plants are grown. This has been very clearly shown by the remarkable series of investigations made by Professor Klebs upon various thallophytes. For a discussion of the meaning of sex, the reader may refer to the recent papers on the subject by Strasburger and Beveri.

In short, while we know to a considerable extent some of the factors which determine the formation of sexual cells, where these have already been developed, the reasons why sex has developed are still very obscure.

Secondary reproductive structures, such as sporangia, seeds, flowers, fruit, etc., are readily enough explicable and need not be dwelt upon here.

PHOTOSYNTHESIS.

Perhaps the most important physiological property of green plants is the photosynthesis, or the ability to utilize the energy of the sun's rays for the manufacture of the primary carbon compounds necessary to build up living protoplasm. That some of the most striking modifications of the plant body are directly associated with photosynthesis is certain. The development of leaves in various groups of plants is, perhaps, the most obvious response to the needs for photosynthesis. The leaf is, *par excellence*, the photosynthetic organ. The spreading out of the green cells so as to offer the most favorable exposure to the light rays, and in the higher plants the development of stomata and the spongy mesophyll, or special assimilating tissues, are especially perfect. Leaves are by no means confined to the vascular plants, however. We need only recall the simple leaves of mosses and liverworts and the similar organs in the more highly organized seaweeds, such as *Sargassum* or *Macrocystis*. Even among the truly green algæ simple photosynthetic organs may be developed. The dense branching tufts of *Draparnaldia* or the expanded frond of *Ulva*, for example, are of this nature.

The leaves of these lower plants are very different morphologically from those of the ferns and seed plants, but show very clearly that they are physiologically of the same nature; *i. e.*, they are *analogous* but not *homologous*.

Other special modifications associated with photosynthesis are the peculiar lacunar tissues found in the thallus of the Marchantiales and in the sporogonium of the true mosses and in *Anthoceros*. In all these instances there are formed, in connection with the green lacunar tissue, more or less perfect stomata. These upon the apophysis of the sporogonium of many mosses, and over the whole surface in *Anthoceros*, are precisely similar to those found upon the leaves and other green organs of the vascular plants.

While it is usually stated that, among the bryophytes, appendicular organs are quite absent from the sporophyte, the apophysis, or special assimilative organ at the base of the capsule in some of the more specialized mosses like *Polytrichum* and *Splachnum*, might almost be so regarded. In the latter genus it sometimes forms a broad disk several times the diameter of the rest of the capsule, and is just as truly a special organ for photosynthesis as is the leaf of a fern or flowering plant.

WATER.

Even more important than the changes of the plant body associated with photosynthesis are those which are due to the plant's relation to the water supply. All organisms require a certain amount of water in order that the protoplasm may perform its functions. Protoplasm is not necessarily killed by the withdrawal of water, but it is rendered inactive, as may be readily seen in such structures as seeds, spores, etc.

The lowest organisms, whether plant or animal, are virtually aquatic; for, although they do not necessarily always remain in a liquid medium, they become quiescent when moisture is withheld. Very many, like most algæ, are true aquatics, and it

is safe to assume that the progenitors of the higher plants lived in the water. The nearest approach to these ancestral forms which have survived are probably certain green algæ, which have retained much of their primitive simplicity. Much the greater number of living plants, however, have given up the primitive aquatic habit for life on land. In adapting themselves to this new habitat they have contrived to exist with a much diminished water supply, which has enabled them to outstrip the much simpler forms which have retained their old aquatic habit.

The change from the primitive aquatic condition to the much more varied conditions of terrestrial existence is bound up with profound changes in the organization of the plant body.

MARINE PLANTS.

Of the existing plants which have retained the primitive aquatic habit, the most important are the various types of marine algæ, including not only the larger seaweeds, but also the minute pelagic forms like the diatoms and Peridineæ. Many of the larger seaweeds are very much better developed than the simple green freshwater algæ, and show many special modifications associated with their peculiar environment. Not being subject to the drying up which threatens all fresh-water organisms at times, it is very rarely that marine algæ develop any form of resting-spores such as are so common among freshwater algæ. On the other hand, those which grow between tide-marks, where they are regularly exposed at low-tide, develop mucilaginous or gelatinous tissues, which prevent too complete loss of water. This is especially well seen in the large kelps and similar forms. Some of these, also, reach an enormous size, and develop leaves which are often provided with bladder-like floats, which bring them to the surface when they are exposed to the light.

Very characteristic are the minute pelagic plants, especially the diatoms and Peridineæ, which are important constituents of the plankton, or surface life of the sea. These floating plants are generally provided with some sort of buoyant apparatus, evidently an adaptation to their pelagic life. Small as these floating algæ are individually, they are immensely important to ocean life, as they constitute the main source of food for the hosts of animals inhabiting the sea.

The great subkingdom of fungi offers many interesting problems bearing upon the evolution of plant-forms, but there is no reason to suppose that any higher types of plants have ever arisen from the fungi, many of which are doubtless plants of comparatively recent origin. Most of their peculiarities are associated with their nutrition, which is entirely different from that of typical plants. Not having chlorophyll, they are, like animals, dependent upon other organisms for food. Consequently all fungi are either saprophytes, living upon dead organic matter, or as parasites they attack living animals and plants.

I can not dwell here upon the extremely difficult problems connected with the origin and affinities of the fungi, even if I felt competent to discuss them.

THE ORIGIN OF TERRESTRIAL PLANTS.

We have now to consider what causes led to the abandonment of the aquatic habit by the algæ ancestors of the vascular plants, and how this radical change in their environment has influenced the development of the structures of the higher plants.

Nearly all fresh-water plants are exposed to destruction at times, by the drying up of the bodies of water in which

they live, conditions which are never met with in the life of most marine organisms. This necessitates some means of surviving the periods of drought, and has resulted in the development of various devices for carrying the plants through from one growing period to another. While a few low aquatics, like *Pleurococcus* or *Oscillatoria*, may become completely dried up without being killed, in most fresh-water algæ there are produced special cells—spores—which are more resistant than the vegetative cells and survive the death of the rest of the plant body. These resting spores may be produced non-sexually, as in *Nostoc*, or the 'aplanospores' of some of the green algæ; but more commonly they are the product of the union of sexual cells, or gametes, and may be generally denominated 'zygotes.'

This condition of things of course precludes growth, except when an abundant water supply is provided. It is evident that any device by which the vegetative life of the plant can be prolonged is an obvious advantage.

Some such contrivances, of a simpler kind, are seen in some of the lower green plants. Thus the gelatinous mass in which the filaments of a *Nostoc* colony are imbedded, or the 'palmella-stage' of some Confervoideæ, offer a certain amount of resistance to the loss of water, and serve to prolong the period of vegetation. Less commonly root-like organs are developed which enable the alga to live on the wet sand, penetrating into it and drawing up water from below. Species of *Vaucheria* and *Botrydium* exhibit this very well.

We may imagine that some algal form, perhaps related to the existing Confervoideæ, adopted a similar amphibious habit, developing rhizoids, by means of which it could vegetate in the mud after the subsidence of the water in which it was growing, in a manner analogous to that exhibited by certain amphibious liverworts still existing. The well-known *Ricciocarpus natans*, for example, lives first as a floating aquatic, but may later settle in the mud, as the water subsides, and there vegetates much more luxuriantly than in its aquatic condition.

The change from a dense medium like water to the much rarer atmosphere necessitates the development of mechanical tissues, to give the plant the requisite support in the air. There must also be developed devices for protecting the tissues against excessive loss of water due to transpiration. Other modifications are to insure economy of water in fertilization.

In submerged aquatic plants water is absorbed directly by all the superficial cells, and of course there is no loss due to transpiration. Moreover, special conducting tissues are made less important, and are either quite wanting, as in most algæ, or much less developed than in related terrestrial forms. As soon as a plant becomes terrestrial there must be provided organs (roots or their equivalent) for drawing up from the earth water to replace what is lost by transpiration, and in all but the simplest forms special conducting tissues to facilitate its transport. In the lower types of land plants, the absorptive organs are usually simple hairs (rhizoids), but these are quite inadequate to supply a plant of large size, and consequently it is only those terrestrial plants which are provided with a true root system that have succeeded in reaching a large size. Even in the lower terrestrial forms the rhizoids do not monopolize the absorption of water, but many of them are able to absorb water directly through the leaves or through the superficial cells of the thallus. While this is especially marked in many mosses and liverworts, which are, so to speak, more or less aquatic in their behavior toward water, it is by no means

confined to them, as most vascular plants develop structures, seeds, tubers, bulbs, etc., which can absorb water directly. Less commonly the leaves of vascular plants have this property. This is especially marked in various xerophilous plants, such as the Californian gold-back fern (*Gymnogramme triangularis*), *Selaginella rupestris* and other species, many species of *Tillandsia*, etc.

As all botanists know, the structural differences between aquatic and terrestrial plants are very marked, but there are some transitional forms which illustrate very beautifully the change from one to the other, and the efforts of the plant to adjust itself to the changed conditions. Thus some plants which are usually strictly aquatic, such as some water-lilies, may assume a nearly terrestrial condition, the long-stalked, floating leaves being replaced by those borne upon shorter upright petioles.

The primitive aquatic plants are either unicellular or simple cellular plants with relatively little differentiation of parts, as might be expected in organisms living in a relatively uniform medium. A necessity for their active existence is an abundant water supply, as they are not provided with any adequate means for resisting desiccation, although the mucilaginous or gelatinous substances in which their cells are sometimes imbedded serve to retard for a short time the loss of water by evaporation when they are exposed to the air. A good many of the lower fresh-water organisms are capable of becoming dried up without losing their vitality, but of course their activity is stopped. More commonly they depend upon special resting cells, or spores, to carry them through periods of drought or cold.

In exceptional cases, the lower algæ may assume an amphibious habit, living upon wet mud instead of actually in the water. *Botrydium* and some species of *Vaucheria* develop a simple root system by which the loss of water by transpiration is made good so long as the soil remains moist; but these quickly die as soon as the mud dries, as their cells are not protected against loss of water by evaporation.

It is, however, among the bryophytes, or mosses, that anything approaching a satisfactory solution of the problem of a terrestrial existence is attained. (I am leaving out of account the fungi.) All of the mosses are, to a certain extent, amphibious, since all of them require first water in order that fertilization may be effected. A small number, *e. g., Riccia fluitans, Riella, Fontinalis,* etc., are genuine aquatics, and the life history of such a form as *Ricciocarpus natans* illustrates what has probably been the origin of the terrestrial habit in the primitive archegoniates. *Ricciocarpus* is usually a floating plant, but it not infrequently assumes a terrestrial habit, sometimes preliminary to developing its reproductive organs. This is brought about by the subsidence of the water until the plant is left stranded on the sand. Under such circumstances it grows very vigorously, develops numerous rhizoids which penetrate the mud and supply it with water. Excessive loss of water is checked by the development of a cuticularized epidermis covering the exposed surface of the thallus. It is highly probable that in some such way as this the algæ ancestors of the first archegoniate plants began their life on land, and slowly emancipated themselves from the necessity of being surrounded by water, and of course thus became more and more independent of the drying up of shallow bodies of water in which they grew. In this way the vegetative period would be much prolonged, and would give the plant a great advantage

over its aquatic competitors, and thus the terrestrial habit was established.

Some liverworts and mosses may reach considerable size, a foot or more in length in a few cases. They also exhibit a certain amount of specialization, corresponding to the requirements of the terrestrial environment. Well-developed leaves are present in nearly all true mosses, and in many liverworts, and in one order of the latter, the Marchantiales, the plant body, while retaining its thallose character, develops a complicated assimilative tissue, with stomata of a peculiar type not found elsewhere. In the upright forms mechanical tissues are developed, and in the true mosses there is present in the leafy shoots a central strand of conducting tissue, comparable to the vascular bundles found in the sporophytes of the vascular plants. Indeed the analogies existing between the leafy moss-shoot and the sporophytic shoots of the vascular plants are sufficiently obvious.

No existing bryophytes have succeeded in reaching any but the most modest dimensions. All the larger forms either are prostrate or grow in dense tufts, offering mutual support to the leafy shoots. Indeed no moss seems to have quite solved the problem of a self-supporting upright leaf-supporting axis. Neither have they successfully solved the problem of an adequate water supply, to compensate for loss of water by transpiration, and this of course is closely associated with the limit of size which the plant-body could assume. Given an unlimited water supply, and a plant, even of low organization, may attain very large dimensions, as we see in the giant kelps. Those plants, although in many respects of very low rank, nevertheless may reach hundreds of feet in length, and develop specialized tissues, curiously suggesting those of the highly organized land plants. These giant seaweeds absorb water throughout their whole superficial area, and there is no loss of water by transpiration; but for a terrestrial plant to reach a large size there must be adequate means for absorbing water from the soil, and for transporting it expeditiously through the plant to those places where water is being lost through transpiration.

In the highest terrestrial plants, the 'vascular' plants, we meet first with a perfect system of water-conducting tissue. This is the woody portion of the fibro-vascular bundles, composed of the characteristic tracheary tissue, first encountered in the ferns, and common to all the higher plants.

ORIGIN OF THE SPOROPHYTE.

Among the lower terrestrial plants, the Archegoniatæ, which comprise the mosses and ferns, a very marked characteristic is the 'alternation of generations.' By this is meant that in its development the plant passes through two very different phases, a sexual and a non-sexual one. This is perhaps best seen in the ferns. The spore of the fern, on germination, gives rise not to the leafy fern plant, but to a much simpler plant much like a small liverwort, upon which the sexual reproductive organs, the archegonium and antheridium, are borne. This sexual plant is known as the gametophyte. Within the archegonium is borne the egg-cell or ovum, which, after being fertilized, ultimately produces the leafy fern plant, or 'sporophyte,' from its producing the spores, or non-sexual reproductive bodies.

Among the lower Archegoniates, the gametophyte is relatively much more important, and the sporophyte is never an independent plant, as it is in the ferns, but always remains to a greater or less extent dependent upon the gametophyte for its existence.

An alternation of generations is hinted at among some of the green algæ, but never becomes sharply defined as it is in the archegoniates. Among the red algæ, however, it becomes clearly marked, and also in many fungi. In both of the latter cases it is extremely probable that we have to do merely with analogies, as there is not the slightest evidence of any genetic connection between either of these groups and the archegoniates.

With the green algæ, however, the case is somewhat different, and it is highly probable that the earliest archegoniates arose from some forms not very different from *Coleochæte*, a green alga in which the fertilized egg gives rise to a very simple sporophytic structure.

The increase in the output of the zygote, or fertilized egg, due to its division into a number of spores, instead of forming at once a single new individual, is an evident advantage which becomes increasingly important as the gametophyte assumes the character of a terrestrial plant, and the chances of fertilization, which requires the presence of water, become correspondingly lessened.

There are two theories as to the origin of the alternation of generations among the archegoniates, the 'homologous' and 'antithetic.' The first holds that the non-sexual sporophyte is a direct modification of the gametophyte and probably arose from it as a vegetative outgrowth. The antithetic theory holds that the sporophyte always, in normal cases, arises from the fertilized ovum, and is a further development of the zygote which has arisen in response to the requirements of a terrestrial existence. There is not time here to consider at length the relative merits of these two theories. In a special paper before the section, I hope to bring this matter up for discussion. For present purposes I shall assume that the latter (antithetic) view is the correct one.

As the ancestors of the archegoniates left their original aquatic habitat, the question of the water supply became of the first importance. All of these lower land plants have retained many of their original characteristics, among them the development of motile male cells (spermatozoids), which require free water in order that they may reach the egg-cell and fertilize it. That is, the plants are, to a certain extent, amphibious, and must return to the water in order that fertilization may be effected. It is very clear, then, that anything which tends to increase the number of spores resulting from the developed zygote will be advantageous, rendering a single fertilization more and more effective.

The alternation of sexual and non-sexual plants among the green algæ is not sharply marked, and has been shown to be largely a matter of nutrition. Nevertheless, as already mentioned, there is a hint of an alternation of generations in certain forms like the higher Confervoideæ. In these the germinating zygote produces a larger or smaller number of zoospores, which give rise to as many new individuals. From some such form as these in all probability the primitive archegoniates arose. As these became distinctly land plants, the motile zoospores resulting from the zygote of the algæ gave place to the non-motile spores characteristic of the terrestrial archegoniates; but of any transitional forms we are quite ignorant, and the gap between algæ and archegoniates is a very deep one.

The gradual specialization exhibited by the existing liverworts and mosses is familiar to all botanists, and will only be briefly discussed here. Enough to say that from the simplest type, a globular mass of spores, with almost no sterile tissue developed, such as occurs in the Ricciaceæ, there are

still found almost all intermediate conditions, culminating in the large and complex sporangia of the true mosses, and the somewhat similar but much simpler one of *Anthoceros.*

In following such a series it is clear that spore-production, the sole function of the primitive sporophyte, becomes largely subordinated to the purely vegetative existence of the sporophyte. Thus in such a moss as *Polytrichum,* the sporogenous tissue does not appear until a late period in the development of the sporophyte, and comprises but a very small fraction of its bulk. An elaborate system of assimilative tissue, with lacunar green tissue and stomata like those of the vascular plants, is developed, and the loss of water due to transpiration is made good by a strand of conducting tissue, which represents a simple type of vascular bundle.

While the elaborate sporophyte of the mosses offers certain suggestions of the structures of the vascular plants, it is much too highly specialized in other directions to make it in the least probable that it has given rise to any higher forms. The equally dependent but much simpler sporophyte of the peculiar group of the Anthocerotales is probably very much more like the forms from which this independent sporophyte of the ferns arose than is the more highly developed sporogonium of the true mosses.

The subject of the gradual elaboration of the sporophyte cannot be dismissed without reference to the very important work of Professor Bower, whose clear exposition of the progressive sterilization of the tissues of the originally exclusively sporogenous sporophyte is one of the most important contributions to the subject.

When we review the extraordinarily large number of resemblances between both gametophyte and sporophyte in the ferns and liverworts, the weight of evidence, to my mind, is overwhelmingly in favor of assuming a real genetic connection between the two groups. To say 'that no structures among plants seem to have left so little trace of its origin as do the leafy sporophytes of Pteridophytes and Spermatophytes,' is certainly to ignore all the principles of comparative morphology. When we reflect that the reproductive organs and mode of fertilization are the same in all archegoniates; that the early divisions and growth of the embryo are identical; that in the more specialized bryophyte the sporophyte develops assimilative and conductive tissues strictly comparable to those of the Pteridophytes; and finally, that the spore formation is identical to the minutest details; surely such a statement is very far indeed from stating the truth.

The fallacy of the arguments based upon apogamy has been ably refuted by Professor Bower. He has called attention to the fact that nearly all cases of apogamy are abnormal, and occur in forms where the sporophyte normally is produced from the egg. It is also noteworthy that the greater number of cases of apogamy occur in extremely variable species, such as the crested varieties of different ferns (*e. g., Scolopendrium vulgare* var. *ramulosissimum*). Professor Bower has also called attention to the fact that these are all forms belonging to the highly specialized and relatively modern group of Leptosporangiatæ. If apogamy is a reversion to a primitive condition, it is strange that it should occur in the least primitive ferns rather than in the older types.

I think we may fairly class the phenomena of apospory and apogamy with the numerous cases of adventitious growths so common among both pteridophytes and seed plants. In these the whole sporophyte may originate as a bud from any

part of the plant. Such adventitious shoots may arise from leaves, as in many ferns, *Begonia, Bryophyllum,* etc.; from roots, in *Ophioglossum,* and many seed plants, *e. g., Populus, Robinia, Anemone,* etc., or even from sporangia, as in the budding of the nucellus of the ovule recorded in several cases of polyembryony. Now, no morphologist would argue from these that they are in any sense reversions, and I can not see why the case of apogamous, or aposporous budding is essentially different.

No bryophytes have quite emancipated themselves from the aquatic habit of their algal progenitors. While they may often dry up for an indefinite period without being killed, there is, nevertheless, much of the same dependence upon an ample water supply that we find in the algæ. Although much more resistant to loss of water through transpiration than are the few terrestrial algæ, nevertheless the bryophytes, as a rule, are much less suited to a genuine terrestrial habit than are the vascular plants. Much the same means are employed by many bryophytes in the absorption of water as by the algæ. Water may be absorbed by all the superficial cells, the roots playing a minor rôle as absorbents, except in those forms in which the plant is a prostrate thallus, where roots are often developed in great numbers. These delicate rhizoids, however, would be quite inadequate to supply the needs of a leafy stem of any but the most modest proportions. In a few bryophytes, *e. g., Climacium,* there are rhizome-like modifications of the shoot, which may to a limited degree be compared to roots, but any proper roots, like those of the vascular plants, are quite absent. It would seem as if nature's attempts to adapt the originally strictly aquatic gametophyte to a radically different environment had been only partially successful, owing to the failure to develop an adequate root system to restore the water lost through transpiration. It may be that the range of variation any structural type may undergo is limited.

If we accept this hypothesis, it may help to explain the significance of the alternation of generations as developed among the archegoniates, and we can understand why the sporophyte has gradually replaced the gametophyte as the predominant phase of the plant's existence. Attention has already been directed to the perfectly well-known fact that sudden marked variations may appear in plants without any apparent cause. The work of De Vries emphasizes this, and refers all radical advances in structures to such mutations, which are clearly distinguished from the variations which occur within the limits of a species, but which can not apparently overstep certain limits.

In accordance with this view it is quite conceivable that the first appearance of the leaf upon the sporophyte may have been comparatively sudden—that is, there may not necessarily have been a long series of preliminary structures leading up to a true leaf.

It has been urged that the antithetic theory of the nature of the sporophyte involves the sudden appearance of a new structure. The fallacy of this claim has been pointed out by Professor Bower, and a little thought will show that no claim is made of the sudden appearance of a new structure. While no strictly intermediate forms are known, there is certainly no difficulty in seeing the essential homology between the rudimentary sporophyte of such an alga as *Coleochæte* and that of *Riccia.* The antithetic theory merely claims that the structure developed from the zygote, which at first is devoted exclusively to spore formation, gradually develops vege-

tative tissue as well, and finally attains the status of an independent plant.

The highly organized sporophyte of the higher archegoniates is connected with the lower types by an almost continuous series of existing forms, and through these with the still simpler structures found in the green algæ. The increased output of spores, with a corresponding number of new plants resulting from a single fertilization, is an obvious advantage, and undoubtedly is the explanation of the origin of the sporophyte.

If we compare the sporophyte of even the simplest liverwort with that of the algæ, there is noted an essential difference. The spores, instead of being motile zoospores, are non-motile, thick-walled structures, adapted to resist drying up—in short, the sporophyte is a structure essentially fitted for an aerial existence. Except in the very lowest types, there is developed a special massive absorbent organ, the foot, which is not unlike the root developed in the higher types, and is very different from the delicate rhizoids of the gametophyte. The latter always shows, to a greater or less degree, its aquatic origin.

From the time that the sporophyte has attained the dignity of an independent existence, its development proceeded on lines very different from those followed by the essentially aquatic gametophyte. As we have seen, the efforts of the latter to assume a terrestrial habit have met with only partial success, and it would appear that nature concluded to try again, taking as a starting point the essentially terrestrial sporophyte, which, as a functionally new development, seems to have proved more plastic than the gametophyte.

From the first, and this I believe to be highly significant, its water supply was obtained indirectly through the medium of a special organ, the foot. It is not important for a consideration of the question whether the foot in all forms is or is not homologous—enough that we find for the first time an organ sufficiently massive to supply all the water needed by the tissues of the developing sporophyte. The foot is a very different organ from the delicate rhizoids of the gametophyte, and much more like the true roots of the vascular plants, which, it is highly probable, arose as further modifications of the foot of the sporogonium of some bryophyte.

With the massive root penetrating the earth and thus establishing communications with the water supply, the sporophyte becomes entirely independent. The possession of an apical meristem in the root allows of unlimited growth, and gradually the massive root system of the higher plants has been evolved, keeping pace with the increase in size of the sporophyte, which, except with rare exceptions, obtains its whole water supply through the roots. Correlated with this increase in size of the sporophyte has been developed the characteristic conducting tissues which constitute the vascular bundles. While rudimentary vascular bundles are found in the sporophyte of many mosses and in *Anthoceros*, the characteristic tracheary tissue, *par excellence* the water-conducting tissue of the vascular plants, occurs only among the latter forms.

With the establishment of the sporophyte as an independent plant, the gametophyte serves mainly to develop the sexual reproductive organs from which the sporophyte arises. While the gametophyte among the lower pteridophytes is a relatively large and independent green plant, sometimes living for several years, it becomes much reduced in size among the more specialized heterosporous types, and may live but a few hours, as in species of *Marsilia*. In such forms little or no chlorophyll is developed by the gametophyte, which depends for its growth upon

the materials stored up in the spore, or even lives parasitically upon the sporophyte, as in *Selaginella,* thus reversing the relation of sporophyte and gametophyte found in the lower archegoniates.

All of these modifications are in the direction of economy of water, in accord with the needs of a more and more pronounced terrestrial habit.

Just as heterospory arose independently in several groups of pteridophytes, so also the seed habit—the final triumph of the terrestrial sporophyte over the primitive aquatic conditions—developed more than once. The female gametophyte, included within the embryo-sac, develops without the presence of free water, and the germinating pollen-spore also absorbs the water it needs from the tissues of the pistil, through which the tube grows very much as a parasitic fungus would do. Except in a very few cases, the male cells of the seed plants have lost the cilia, the last trace of their aquatic origin, and are conveyed passively to the egg-cell by the growth of the pollen-tube.

Once firmly established as terrestrial organisms, and the problem of water supply solved, the further development of the seed plants is too familiar to need any special comment here. The great importance of water in affecting the structure of land plants is seen in the innumerable water-saving devices developed in the so-called 'xerophilous' plants, seen in its most extreme phase in such desert plants as cacti, or in the numerous epiphytes, like many orchids and bromeliads.

In short, it is safe, I think, to assert that of all the extrinsic factors which have affected the structure of the plant body, the relation to the water supply holds the first place. The most momentous event in the development of the vegetable kingdom was the change from the primitive aquatic habit to the life on land which characterizes the predominant plants of the present.

Douglas Houghton Campbell.

SECTION A, MATHEMATICS AND ASTRONOMY.

Vice-President—Professor George Bruce Halsted, Austin.

Secretary—Professor Charles S. Howe, Cleveland.

Member of Council—Professor John M. Van Vleck.

Sectional Committee—Professor G. W. Hough, Vice-President, 1902; Professor E. S. Crawley, Secretary, 1902; Professor G. B. Halsted, Vice-President, 1903; Professor C. S. Howe, Secretary, 1903; Professor Ormond Stone, five years; Professor J. R. Eastman, four years; Dr. John A. Brashear, three years; Professor Wooster W. Beman, two years; Professor Edwin B. Frost, one year.

General Committee—Mr. Otto H. Tittmann.

Papers were read as follows:

Deflections of the Vertical in Porto Rico: Otto H. Tittmann, Superintendent U. S. Coast and Geodetic Survey.

Mr. Tittmann gave an account of some large deflections of the plumb line in Porto Rico. Their existence was first noted by Count Canete del Pinar, of the Spanish Hydrographic Commission, which extended a triangulation around the island, but the war or other causes prevented a verification by that commission. The Coast Survey, however, in the course of its surveys extended a triangulation across the island from San Juan to Ponce and proved their existence beyond question. These deflections are so great that they affect the cartographic representation of the island, and a mean latitude had to be adopted, with the result that the northern coast line, as now shown on the maps, had to be moved by half a mile further south and the southern coast line by the same amount further north than would have been the case if the astronomical latitude had been used.

Saint Loup's Linkage: Professor L. G. WELD, University of Iowa.

The linkage described by M. Saint Loup in the *Comptes Rendus* for 1874 was discussed with reference to its application to the solution of cubic equations. An instrument constructed upon the principle in question was exhibited and operated. The failure of the device to give the numerically greatest root, or the single real root, was pointed out and explained. Attention was also directed to the fact that this root corresponds to a conjugate point of the locus traced by the linkage and can not, therefore, be reached by continuous motion in the plane of reals.

A Device to Prevent Personal Equation in Transit Observations: Professor S. P. LANGLEY, Secretary of the Smithsonian Institution.

Read by title.

The Solar Constant and Related Problems: S. P. LANGLEY, Secretary of the Smithsonian Institution.

Our absolute dependence on the light and warmth received from the sun makes the study of solar radiations of the highest utilitarian value, even apart from their scientific interest. So little is even now certainly known about the actual amount of the solar radiation, and the absorption of it which the solar gaseous envelope and the earth's atmosphere together cause, that it is doubtful if any one can predict just what influence a given change in the total radiation of the sun would produce on earthly warmth and life.

Early work of the author at Allegheny and upon Mt. Whitney relating to these studies was referred to, however, as showing certain limits within which important predictions could be made, and then attention was drawn to the present investigations of the Smithsonian Astrophysical Observatory. The great improvements in instrumental equipment within recent years were pointed out. Charts were exhibited illustrating how the total radiation expressed in terms of each wave-length as it reaches the earth was accurately represented, by means of an observation lasting only a few minutes, where formerly over two years' labor were required to do still less. Other charts showed how these amounts were corrected, step by step, until the rate of the sun's radiation on the outside of the earth's atmosphere (commonly known as the solar constant) is determined.

The absorbing action of water vapor in the air was shown by a chart of results extending from March to November. It was stated that a yearly cycle of these absorption effects is recognized.

Attention was especially called to the probably great utilitarian importance of variations of absorption in the solar envelope, in their effect upon all life, and to the consequent utility as well as scientific interest of the work now being renewed here to determine this with hitherto unknown fullness.

Good Seeing: S. P. LANGLEY, Secretary of the Smithsonian Institution.

Astronomers have at all times been hindered in all delicate observing by the disturbances arising in our own atmosphere, even in clear weather. The ill effect of these disturbances on the telescopic image is known commonly as 'boiling' (as contrasted with 'good seeing'), and it is the great enemy to accurate observation. Within recent years, therefore, there has been a movement to establish observatories in the most favorable localities to avoid this difficulty, regardless of all considerations of convenience. The author who has made a special study of the subject on mountain tops and elsewhere, has been led to think that the major part of the disturbance arises in the air comparatively

near the observer. He has accordingly attempted so to act on this nearer body of air as to prevent what may be assumed to be the main cause of the 'boiling.'

To do this, it has hitherto been sought by astronomers to keep the air in the telescope tube as still as possible. What may be assumed to be novel in the writer's plan is to vigorously churn this air by means of blowers, or in other ways. The still air is known to produce a disturbed image. That the air agitated under this new plan paradoxically produces a still image, has been shown by photographs (exhibited) of the images of artificial double stars whose beams were entirely confined within a horizontal tube in which they traveled to and fro through 140 feet of 'churned' air. These photographs showed that the disturbance within the tube itself appears to be wholly eliminated by the device of vigorously stirring the air column.

In continuation of the experiments, a tube was pointed up toward the sky, and so moved as to roughly follow the sun and thus form an inclined addition to the telescope tube itself. Within this tube the air was similarly churned. Very considerable improvement of the solar image resulted from the whole combination, but owing to the condition of the sun, the weather and the apparatus, the work has not yet reached a stage where it can be shown that improvement was due to the extension toward the sun, distinctly from the agitation in the tube.

The merit of churning the air within the telescope tube itself is believed to be demonstrated by these photographs, which show the results of this artificial 'good seeing.'

The Foundations of Mathematics: Dr. Paul Carus, Editor Open Court Publishing Co., Chicago.

Having briefly sketched the history of metageometry from Euclid to the present day, he declared that the problem was not mathematical but philosophical. At the bottom of the difficulty there lurks the old problem of the *a priori*. Kant wrongly identified the ideal with the subjective, and thus he regarded the *a priori* as a conception which the mind by its intuitive constitution transfers upon the object. The *a priori*, however, is purely formal, and the purely formal is an abstraction from which everything particular, viz., the sensory, is omitted. It can best be characterized as 'anyness'; it is a construction that would suit any condition, hence universality is implied and universality involves necessity.

There are two kinds of *a priori*, the *a priori* of being, which is pure reason, and the *a priori* of doing, a construction that is the result of pure motion. Our metageometricians tried to derive the basic geometrical principles from pure reason but failed. The truth is that other systems of geometry are possible, yet after all, these other systems are not spaces, but other methods of space measurements. There is one space only, although we may conceive of many different manifolds, which are contrivances or ideal constitutions, invented for the purpose of determining space.

The speaker developed space by motion in all directions after the analogy of the spread of light, and characterized the straight line as the path of greatest intensity corresponding to the ray.

Clifford derives the plane by grinding down three bodies until the three surfaces are congruent. The main feature of the plane is that it is congruent *with itself*. It can be flopped, and in either case it divides space into congruent halves. If we halve the plane, which can be done by folding a piece of paper, we have in the crease a representation of the straight

line; and if we double the folded paper upon itself (another method of halving it), we have the right angle. The three planes at right angles are the simplest systems of a combination of these products of halving.

The speaker concluded that Euclidean geometry is a construction *a priori* of both pure being and pure doing, that other geometries are possible, but that no other is so practical as the one which utilizes the straight line, the plane, and the right angle, viz., the boundaries that are congruent with themselves. Further explanation of his views may be expected in articles to be published in the coming year.

Evidences of Structure in the Mass of the Sun: Professor FRANK H. BIGELOW, U. S. Weather Bureau.

This paper discussed the distribution in longitude and latitude of the output of solar energy as shown by the relative frequency of the prominences, spots and faculæ. The observations used were those made in Italy by Secchi, Tacchini and Ricco during the years 1872 to 1900, and as they form a very regular series, the annual variations are comparable and indicate real changes in the transmission of energy from the interior of the sun to the outside. The result is to show that in longitude there is a maximum of spots, faculæ and probably prominences on two opposite sides of the sun, as if there exists in one axial direction an excess of impulse over that at right angles to it. The same distribution on one diameter has been detected already in the terrestrial magnetic field and in the meteorological elements. In latitude it is shown clearly that, on recovering from a quiescent state at minimum output, the new outpouring of energy takes place in middle latitudes, 25° to 50°, and during the increase spreads in two crests, one towards the equator and one towards the poles, the former dying away near the equator and the latter in about latitude 60°. The connection that probably exists between this phenomenon and the Helmholtz-Emden distribution of heat curves in the interior of the sun indicates a very important type of circulation which may prove to be characteristic of the sun. Incidentally, the paper discussed the rotation period in different latitudes, and the application of the periodgram to such a problem.

Spectrographic Proof of the Rotations of the Planets Jupiter, Saturn and Venus: PERCIVAL LOWELL, Director, Lowell Observatory.

Read by title.

The Teaching of Geometry: Professor GEORGE BRUCE HALSTED, Austin, Texas.

Of late, very remarkable discoveries have been made in geometry, affecting its very foundations. These discoveries have a noteworthy application to the teaching of geometry. Some of these discoveries and applications are considered in abstract as follows: (1) The time has come for advance, (2) need for a preliminary course, (3) the preliminary must fit the rational geometry, (4) rigor gives simplicity, (5) Euclid's unannounced assumptions, (6) the betweenness assumptions, (7) superposition, (8) congruence and symmetry, (9) the real beginnings, (10) the definition of straight as shortest, (11) double import of problems, (12) use of figures, (13) graphics, (14) necessity for non-Euclidean geometry, and (15) adaptation to teaching.

Special Periodic Solutions of the Problem of n Bodies: Professor E. O. LOVETT, Princeton University.

This note constructs analytically the particular solutions of Lehmann-Filhés in the problem of *n* bodies analogous to those of Lagrange in the classic three-body problem.

The method of Poincaré is then used to design other periodic solutions; by an easy reduction the equations become amenable to the treatment proposed by Oppenheim in the corresponding case of three bodies.

The Problems of Three or More Bodies with Prescribed Orbits: Professor E. O. LOVETT, Princeton University.

This paper has points of contact with and generalizes certain theorems due to Bertrand, Darboux, Halphen and Oppenheim. Two problems are studied:

1. The determination of the curves which three bodies may describe under central forces possessing a force function, this function to have a form assigned in advance. The results, other than those which are well known, are transcendental.

2. The determination of forces which maintain the motions of any number of bodies in prescribed orbits independent of initial conditions in a space of any number of dimensions, the forces assumed central. It appears that in general a certain number of the forces may be chosen arbitrarily. In ordinary three-dimensional space this indetermination can not be made to disappear; the solution not becoming determinate until the case of those bodies in the plane is reached.

Note on the Secular Perturbations of the Planets: Professor ASAPH HALL, Professor of Mathematics, U. S. Navy (retired).

It is known that the determination of the secular perturbations of the principal planets of our solar system depends on the solution of an equation of the eighth degree. The roots of this equation depend on the masses of the planets; and if the masses are changed the values of the roots will change also. In this paper an example is given of the changes in the roots, from one set of masses to another, by means of the formulas computed by Stockwell. The results indicate that the formulas of Stockwell can be used with advantage, and that the labor of solving the equation of the eighth degree can be much diminished.

The Bolyai Centenary: Professor G. B. HALSTED, Professor of Mathematics, University of Texas.

On the fifteenth of December, 1902, is the centenary of the discoverer of non-Euclidean geometry, the Hungarian John Bolyai, or, in Magyar, Bolyai Janos. This extraordinarily important and suggestive subject, non-Euclidean geometry, in its inception, evolution, present state and near future development, was treated in this paper.

The Approach of Comet b 1902 to the Planet Mercury: CHARLES J. LING, Manual Training High School, Denver, Colorado.

The questions treated were:

The exact position of comet and planet at time of nearest approach: to obtain accurately distance between the bodies at this time.

The great velocity of comet near perihelion together with the position of orbit takes the comet away from Mercury very rapidly. The effect of Mercury at distance of $2\frac{1}{3}$ millions of miles very slight.

Very questionable, if any, effect will be produced by Mercury which will enable astronomers to tell anything about mass of Mercury.

An Untried Method of Determining the Constant of Refraction: GEORGE A. HILL, U. S. Naval Observatory.

This paper called attention to a method of deriving the constant of refraction from transits of pairs of stars in the prime vertical. Remarks were first made upon our present knowledge of the constant as secured from observations of stars at upper

and lower culmination, either by means of the meridian or the vertical circle. A plan was then suggested by which the constant might be secured by proper groups of stars in pairs, observed in the prime vertical.

A Development of the Conic Sections by Kinematic Methods: JOHN T. QUINN, Warren, Pennsylania.

The paper is an abstract of a more general system of kinematic geometry whereby not only the conic sections, but nearly all the higher plane curves are developed by kinematic methods. The following definition will give some idea of its scope:

Kinematic geometry treats of the properties of the areas and curves regarded as functions of the spacial and angular velocities of lines, which move in accordance with some fixed law.

With reference to the conic sections (as those are the curves in which we are at present interested), the originality of their development consists in the introduction of an auxiliary circle, called the directing circle; and the conditions subject to which the intersecting lines are assumed to revolve. The lines are pivoted in an axis and conceived to revolve and move at such rates that certain angles are constantly equal, then the locus of their intersection is a conic section.

That this mode of development makes manifest more than any other the essential unity of the curves, and their dependence upon the same law of generation, is evidenced by the general definition of a conic in this system, referred to a common property.

A conic section is a curve the ratio of the distances of whose points form a fixed point and a directing circle is equal to unity. For the ellipse and parabola, the fixed point (a focus) is in the diameter of the directing circle, for the hyperbola, in the diameter produced.

The problem of constructing tangents to either of the curves from external points in their plane is solved in an extremely simple manner. The mode of procedure is essentially the same for each of the curves. This problem is facilitated by the directing circle, which becomes the directrix of the parabola when the circle becomes infinite.

The point on either of the curves which is common to the tangent through the external point is located by drawing only two lines.

The normal to a curve always is parallel to one of the generating lines. Consequently, as a problem in construction it presents no difficulty whatever.

To construct asymptotes to the hyperbola we have only to describe a circle, upon the line as a diameter, which is limited by the center and the focus. It intersects the directing circle in two points, which, with the center, determine the direction and position of both lines.

Time Determinations at the Washburn Observatory: Professor GEORGE C. COMSTOCK, Madison, Wisconsin.

This was a discussion of methods employed in the time service of the Washburn Observatory, with especial reference to the advantages to be obtained by a reversal of the instrument upon each star.

Determination of Time by Reversing on Each Star: Professor CHARLES S. HOWE, Case School of Applied Science, Cleveland, Ohio.

Complete determinations of time were made on several nights by the usual method with clamp west and also with clamp east. On the same nights determinations of time were also made by reversing on each star. The clock errors were compared with those found with the almucantar. A table of azimuths, clamp west and clamp east was given, and it

was shown that the instrument changed greatly in azimuth by reversal.

Note on a Geometrical Analysis: Professor JAMES S. MILLER, Emory Virginia.
Read by title.

Concerning Bolzano's Contributions to Assemblage Theory: Dr. C. J. KEYSER, Columbia University, New York City.
Read by title.

The Constants of the Equatorial: C. W. FREDERICK, U. S. Naval Observatory, Washington, D. C.

This paper contained a description of a method for deriving the constants of an equatorial from observations of circumpolar and equatorial stars. The position of the polar axis of the instrument is determined from observations of λ Ursæ Minoris and Polaris near the times of culmination and elongation; also other constants are involved. Collimation and the flexure of the tube are derived from observations of equatorial stars. Very simple formulæ are required in the reduction of these observations.

The effect of the constants in varying the parallel of the micrometer is also considered, and a short process indicated by which micrometer measurements may be corrected for these instrumental disturbances without undue labor.

A Relation between the Mean Speed of Stellar Motion and the Velocity of Wave Propagation in a Universal Gaseous Medium, Bearing upon the Question of the Nature of Ether: LUIGI D'AURIA, 3810 Locust Street, Philadelphia, Pa.

If the universe were involved in a primordial gaseous medium in equilibrium of temperature, then assuming the density to vary inversely with some power, n, of the distance from the center of this universal gaseous globe, which would be the center of the universe, it is found that $n=2$, or the density varies inversely with the square of distance. If ω and ω_0 denote respectively the density of the medium at any distance z and the mean density of the concentric sphere of radius z, then

$$\omega_0 = 3\omega$$

and

$$\omega = \frac{\overline{u}^2}{6\pi k z^2}$$

in which $\bar{u}$ is the mean square speed of the particles of the medium and K the gravitation constant.

Denoting by σ the density of the medium in the solar system, and by S the distance of this system from the center of the universe, it is found that

$$\sigma = \frac{\overline{u}^2}{6\pi K S^2}.$$

Bodies moving in circular orbits around the center of the universe, at all distances, would all have the same velocity

$$v_0 = 2S\sqrt{\pi k \sigma},$$

and it is found that $\bar{u}^2 = 3/2 v_0^2$; and if V is the speed of wave propagation in the gaseous medium, it is found also that $V^2 = 5/6 v_0^2$. As v_0 must be nearly equal to the mean speed of stellar motion, about 19.3 miles per second according to Kapteyn, it is concluded that the ether can not be a gravitational gas, since this gas could not transmit energy with velocity much greater than 17.6 miles per second. Hence, the ether must be imponderable.

Denoting by R and D the mean radius and the mean density of the earth, and by g the acceleration of gravity, it is shown that

$$\sigma = \tfrac{1}{3}\frac{RD}{g}\left(\frac{v_0}{S}\right)^2,$$

and assuming $S=159$ light years, an estimated distance of Nova Persei, and as-

suming this star to be near the center of the universe, it would follow that

$$\sigma = 3.9 \times 10^{-19} d$$

in which d is the density of ordinary air. That is, the density of the universal gaseous medium in the solar system would be of the same order of magnitude as the ether. On this basis the density of the medium at a distance of 585,000 miles from the center becomes equal to that of ordinary air, and the concentric sphere of the medium within this radius would have a mass about seven times that of Jupiter, a mass entirely too small to be conspicuous in celestial space.

Condition of Atmosphere, Horizon, and Seeing at the Lowe Observatory, Echo Mountain, California: Professor EDGAR L. LARKIN, Director Lowe Observatory. Read by title.

The officers elected for the next meeting are:

Vice-President—Otto H. Tittmann, Superintendent United States Coast and Geodetic Survey.

Secretary—Professor Laenas G. Weld, University of Iowa.

CHARLES S. HOWE,
Secretary.

SCIENTIFIC BOOKS.

Ueber den derzeitigen Stand der Descendenzlehre in der Zoologie. Von DR. H. E. ZIEGLER, Professor an der Universität Jena. Gustav Fischer. 1902. Pp. 54, with 4 text-figures. M. 1.50.

On the occasion of the seventy-third meeting of the German Naturalists and Physicians in Hamburg, September, 1902, the general question of the present status of the doctrine of organic evolution was presented in three lectures—by a botanist (de Vries), a paleontologist (Koken) and the zoologist, Ziegler. The last lecture is now somewhat extended by notes and appendices and published under the title given above.

It is an interesting account of the present standing of the great *Descendenzlehre* in zoology, given in a temperate spirit; a good lecture for the occasion and the place in which it was delivered.

The subject is considered under four sections: (1) The general theory of organic evolution, (2) natural selection, (3) inheritance theories and (4) the application of evolution to the origin of mankind.

Of these, the first section is treated with a firmer hand, as is justified by the state of our knowledge, and the author reviews interestingly, from the zoological side, some of the evidences in support of evolution. He points out that the general proposition has been so strengthened by the researches of the past forty years that all naturalists agree in accepting it as established. We have no other rational theory of the origin of plants and animals, and, notwithstanding the controversies as to the factors that have brought about the diversity of organic life, the fact of evolution as a process of creation is no longer seriously challenged.

But the compelling arguments in support of evolution do not hold in equal force for natural selection or any other particular theory. Here we have conflicting opinions, but they do not seriously affect the main contention. As Huxley, one of the greatest supporters of natural selection, said: 'If the Darwinian hypothesis were swept away, evolution would still stand where it was,' and the same thing can be said in reference to any theory of evolution that has been offered since.

In regard to natural selection, Ziegler comes to the position of so many working zoologists, that as a factor it is not adequate by itself to afford an explanation of variation and development. In many instances its action is clear—as when variations which are of direct use to the animal are fostered by natural selection, but many other cases like the great development of the backward-directed tusks of the mammoth, and horns of other animals, can not be explained by natural selection.

The third section is more lightly treated. The inheritance theories of de Vries, Nägeli, Haacke and Weismann receive passing men-

tion, but the intricacies of the subject prevented the lecturer from entering into a discussion of them.

In reference to the applicability of evolution to man's origin, the evidences in favor of an affirmative answer have been growing. The discovery, in 1894, of remains of an intermediate type between the higher apes and man—*Pithecanthropus erectus*—bears upon the question. The intermediate character of that form was well brought out by the opinions expressed by competent anatomists, some declaring the remains to be of an ape-like form and others of primeval man.

But more suggestive evidences are found in the comparative study of animal intelligence and of the structure and physiology of the brain. There is a gradual increase in intelligence with increase in complexity of the brain, and the discovery of localized areas presiding over definite coordinated acts brings evidence of the close relation between brain structure and mentality. Clinical studies and criminal anthropology show that disorders of the will and mental derangements are dependent upon disorders of the nervous system. Man can not be separated in his development from other animals; he differs from them in the degree of his development, and his nobility depends, not on his origin, but on how far he is advanced beyond it.

The text of the lecture is followed by six appendices, made up largely of apt quotations which help to show the state of opinion and to illuminate some points of the lecture.

William A. Locy.

Oeuvres Complètes de J.-C. Galissard de Marignac: Hors-série des Mémoirès de la Société de Physique et d'Histoire Naturelle de Genève. Geneva, Eggimann et Cie.; Paris, Masson et Cie, et al. Vol. I. 4to. Pp. lv + 701.

The collected publication of the scattered writings of a great scientific man forms one of the most adequate and fitting memorials of him, because it enables many otherwise ignorant to perceive the way in which he attained greatness. The present volume, which covers twenty years of the life of the eminent Swiss chemist, is no exception to this rule. It contains, in the first place, an interesting biography by E. Ador, filling the first fifty-five pages, and after this Marignac's papers on atomic weights, crystallography and other chemical and physicochemical subjects, arranged in chronological order, as far as 1860.

These papers form a notable record of unusual ability, enthusiasm and perseverance, of which any nation may well be proud. Only one lack is to be noticed in the present publication, in common with many other French books, namely, the lack of an index. This deficiency may well be supplied in the second installment; for it is to be hoped that this handsome volume will soon be followed by another, completing the record.

Theodore William Richards.

SOCIETIES AND ACADEMIES.

AMERICAN MATHEMATICAL SOCIETY.

During the Christmas holidays the American Mathematical Society held a series of three meetings, at New York, Chicago and San Francisco. The ninth annual meeting of the entire society was held at Columbia University, on Monday and Tuesday, December 29–30. The San Francisco Section held its second regular meeting at the University of California, December 23. The Chicago Section met at the University of Chicago, January 2–3. The meetings were well attended. The several programs included some fifty papers, being about one third of the society's annual production. Ten years ago the United States hardly produced one sixth of this amount of mathematical material. The comparison fairly represents the recent great advances in mathematical interest in this country.

Reports of the sectional meetings will appear separately in Science. The annual meeting, at New York, was attended by sixty members of the society. Twenty-six papers were read at the four sessions. The council announced the election of the following persons to membership in the society: Dr. A. B. Coble, University of Missouri; Mr. W. R. Cornish, State Normal School, Cortland, N.

Y.; Dr. A. G. Hall, University of Michigan; Mr. E. L. Hancock, Purdue University; Professor L. M. Hoskins, Stanford University; Mr. W. D. A. Westfall, Yale University; Mr. W. F. White, State Normal School, New Paltz, N. Y. Sixteen applicants for admission to the society were received.

At the annual election the following officers and members of the council were chosen:

President, Thomas S. Fiske.

Vice-Presidents, W. F. Osgood, Alexander Ziwet.

Secretary, F. N. Cole.

Treasurer, W. S. Dennett.

Librarian, D. E. Smith.

Committee of Publication, F. N. Cole, Alexander Ziwet, D. E. Smith.

Members of the Council, to serve until December, 1905, James Harkness, Heinrich Maschke, Irving Stringham, H. W. Tyler.

The report of the librarian shows that the society's library, which was recently deposited in the charge of the Columbia University Library, is rapidly growing and already contains nearly one thousand bound volumes. The exchange lists of the *Bulletin* and the *Transactions* now include about one hundred and twenty mathematical journals, being nearly all that exist. Many gifts have also been received. It is hoped that the society's collection may ultimately become the most extensive one of the kind in the country. Besides the mathematical journals of the world, it is intended to include a full set of mathematical Americana, thus making the library a historical as well as mathematical repository.

A special feature of the annual meeting this year was the presidential address. Under the title: 'On the Foundations of Mathematics,' the retiring president, Professor Eliakim Hastings Moore, advocated the desirability of the society exercising a more effective influence on the teaching of elementary mathematics. The address will appear in SCIENCE. A committee was appointed by the council to consider the questions involved.

The following papers were read at the annual meeting:

E. V. HUNTINGTON: 'A complete set of postulates for the theory of real number' (second paper).

E. V. HUNTINGTON: 'On the definition of the elementary functions by means of definite integrals.'

C. J. KEYSER: 'On the axiom of infinity.'

G. H. DARWIN: 'The approximate determination of the form of Maclaurin's spheroid.'

HARRIS HANCOCK: 'Remarks on the sufficient conditions in the calculus of variations.'

L. E. DICKSON: 'The abstract group simply isomorphic with the alternating group on six letters.'

PRESIDENT E. H. MOORE: Presidential Address, 'On the foundations of mathematics.'

W. E. TAYLOR: 'On the product of an alternant and a symmetric function.'

E. D. ROE: 'On the coefficients in the product of an alternant and a symmetric function.'

E. D. ROE: 'On the coefficients in the quotient of two alternants (preliminary communication).'

E. O. LOVETT: 'A transformation group of $(2n-1)$ $(n-1)$ parameters, and its rôle in the problem of n bodies.'

I. E. RABINOVITCH: 'On solid lunes of conicoids, analogous to the circular lunes of Hippocrates of Chios.'

E. B. WILSON: 'The synthetic treatment of conics at the present time.'

A. B. COBLE: 'On the invariant theory of the connex (2, 2) of the ternary domain viewed as a connex (1, 1) in a five-dimensional space.'

EDWARD KASNER: 'The general quadratic systems of conics and quadrics.'

W. F. OSGOOD: 'On the transformation of the boundary in the case of conformal mapping.'

W. F. OSGOOD: 'A Jordan curve of positive area.'

MAXIME BÔCHER: 'Singular points of functions which satisfy partial differential equations of the elliptic type.'

J. W. YOUNG: 'On the automorphic functions associated with the group of character $[0, 3; 2, 4, \infty]$' (preliminary report).

R. W. H. T. HUDSON: 'The analytic theory of displacements.'

H. E. HAWKES: 'Enumeration of the non-quaternion number systems.'

H. F. STECKER: 'On the parameters in certain systems of geodesic lines.'

G. D. BIRKHOFF and H. S. VANDIVER: 'General theory of the integral divisors of $a^n - b^n$, and allied cyclotomic forms.'

F. MORLEY: 'On the determinant $|(x_i - a_j)^{-2}|$.'

G. A. Miller: 'A new proof of the generalized Wilson's theorem.'

A pleasant social feature of the meeting was an informal dinner on Monday evening at which about forty persons were present.

The next meeting of the society will be held in New York on Saturday, February 28. Arrangements are being made for the coming summer meeting and colloquium, to be held in August or September.

F. N. Cole,
Secretary.

THE NEW MEXICO ACADEMY OF SCIENCE.

A New Mexico Academy of Science was formed at Las Vegas, N. M., on December 22. The following officers were elected for the ensuing year:

President, Frank Springer.

Vice-President, Dr. Chas. R. Keyes.

Secretary and Treasurer, Dr. W. G. Tight.

Members of Executive Committee, T. D. A. Cockerell, J. D. Tinsley.

The following papers were read:

W. G. Tight: 'The Erosion Cycles of the Rio Grande at Albuquerque.'

E. L. Hewett: 'Notes on the Pecos Indian Tribe.'

H. N. Herrick: 'The Gypsum Deposits of New Mexico.'

J. D. Tinsley: 'The Work of the Department of Soils and Physics of the New Mexico A. and M. College and Experiment Station.'

E. L. Hewett: 'An Archeological Reconnaissance of the Chaco Cañon Region.'

C. E. Magnusson: 'Observations on Soil-moisture in New Mexico from the Hygienic Viewpoint.'

T. D. A. Cockerell: 'Our Present Knowledge of the Fauna and Flora of New Mexico.'

John Weinzirl and C. E. Magnusson: 'Further Contributions to the Study of the Blood Changes Due to Altitude.'

John Weinzirl: 'The Availability of New Mexico's Climate for Outdoor Life.' (Read by title only.)

W. G. Tight: 'The History of the Sandia Mountains.'

T. D. A. Cockerell.

DISCUSSION AND CORRESPONDENCE.

MARINE ANIMALS IN INTERIOR WATERS.

The recent accounts of the finding of squid in Lake Onondaga, New York, recall two similar instances that were brought to the attention of the U. S. Fish Commission several years ago.

The commission received for identification from Northern Michigan a specimen of remora (*Echeneis naucrates*), with the information that it had been caught by an Indian woman in a trout stream on the southern shore of Lake Superior. There was no reason to doubt the facts from the evidence contained in affidavits which were quickly produced. The true inwardness of this matter has never been cleared up, although it was learned that a New York City sportsman had been to this region a short time before and had been in the company of the man who forwarded the specimen.

By a singular coincidence, which must be of interest to psychologists and telepathists, at the time the Indian squaw was catching a remora in a Michigan river a Washington angler was landing another at the Great Falls of the Potomac, 16 miles above Washington and 60 miles from salt water. This specimen was brought to the Fish Commission the next day by the man who caught it, and whose ingenuousness there was no reason to doubt. Later, several of his friends called and explained that they had bought the fish in the market and attached it to his line when his attention was diverted.

On the authority of Professor Hargitt, of Syracuse University, a sargassum fish (*Pterophryne histrio*), said to have been caught in Onondaga Lake, was exhibited in Syracuse some years ago. H. M. Smith.

A BRILLIANT METEOR.

To the Editor of Science: On the evening of November 15, at 6:45 central standard time, a very brilliant meteor was observed in its fall to the earth by many persons in the states of Ohio, Kentucky, Tennessee, Louisiana, Mississippi, Alabama and Georgia. At once, though at first independently of each

other, Professor H. C. Lord, of the Emerson McMillan Observatory, Columbus, Ohio, and the writer began a series of investigations with a view to determining where it should have fallen. We secured reports from some twenty-five or thirty observers scattered over the states mentioned above; none of them, however, were expressed very definitely in terms of angular measurements, excepting those of Professor Lord and myself, and we evidently had not noted the altitude and azimuth of the meteor at exactly the same point of its descent. Satisfied, however, that if any pieces came to the earth, they must have fallen somewhere between Lexington and a point in Elliott County, Ky., where an observer saw the meteor to the west of him, I was induced to hunt down a rumor that it had fallen in Bath County, and was rewarded by finding that it had indeed come to earth in the extreme southern portion of that county, and had been picked up by the man who saw it strike the ground. The exact point struck was a stone in the road in front of the home of Mr. Buford Staten, five miles due south of Salt Lick, Ky.

The stone (for it is an aerolite) is roughly $8\frac{1}{2} \times 6 \times 4$ inches, has a volume of 1,642 c.c., and now weighs, with some pieces chipped off for analysis, 5,725 grms., or about 12 lbs. $10\frac{1}{2}$ oz. It exhibits the usual black crust or varnish, the pittings, the grayish interior, and shows on analysis the disseminated nickeliferous metallic iron.

It is interesting to note that, though the approximate place of this aerolite's fall was not determined by calculations based upon observations giving the azimuths of the point where it appeared to burst as seen from different stations—the meteorite itself having been brought in before our investigations had reached the calculating stage—yet had it not been seen to strike the earth, it is not improbable that it would soon have been found as a result of special search. A projection of the lines of observation in accordance with the azimuths of the Columbus and Lexington determinations (S. 15 degrees W., and N. 81 degrees E.) cross in the southern portion of Bath County, Ky.

Note.—Since writing the above the metorite has been purchased by Mr. Henry Ward for the Ward-Coonley Collection of Meteorites now on deposit in the American Museum of Natural History, New York city.

ARTHUR M. MILLER.
STATE COLLEGE OF KENTUCKY.

AN APPLICATION OF THE LAW OF PRIORITY.

THE first serious attempt to make regulations for the nomenclature of zoology was by a committee of the British Association for the Advancement of Science in 1842. Since then these rules have been both changed and added to, and may still be modified by the action of future zoological congresses. Nomenclature can never be stable so long as the rules are subject to modification. Why then not apply the law of priority to these rules, and declare that the 1842 rules of the British Association must stand, since they have the priority. Of course there were earlier attempts, just as there were binomials before Linnæus and Darwinism before Darwin, but all acknowledge that the 1842 action was the first serious work on zoological nomenclature. Therefore, following the law of priority, they should not be changed. Additions, of course, should be allowed, and these should also follow the law of priority. This would forever prevent change. The scheme of having a zoological congress to meet at intervals, for the discussion and decision of questions, permits of change; and no one can tell how slight or how great these changes may be in the future. Stability can only be obtained by deciding that something already accomplished can not be changed. NATHAN BANKS.

CURRENT NOTES ON PHYSIOGRAPHY.

GLACIAL CHANNELS IN WESTERN NEW YORK.

FAIRCHILD's recent work on the 'Pleistocene Geology of Western New York' ('N. Y. State Museum, 20th Rep. State Geol.,' 1900 (1902), 103–139, plates and maps) includes the most complete statement yet made regarding those remarkable channels worn by rivers that followed temporary courses along the depression enclosed by the spurs of the Allegheny plateau on the south and the face of the retreating

ice sheet on the north. The channels are shown to vary with the character of the rock in which they are cut. The stronger limestones were most worn down where they were cut through to weaker shales, and channels of this kind often have a shallow up-stream floor, separated by a cliff—the site of an ancient waterfall—from a deep gorge with steep walls. Channels cut in shales are often deep all along their length, but their walls are weathered to moderate slopes and their beds are thereby narrowed. Many channels have no northern bank, for the ice that restrained their river on the north has melted away. Some of this kind are to be seen from the N. Y. Central Railroad near Oneida, where the track lies on the ancient river bed. Several small lakes are described as occupying 'plunge-basins' excavated beneath cataracts.

THE SCENERY OF ENGLAND.

'The Scenery of Switzerland,' by Sir John Lubbock, is now followed by 'The Scenery of England' by the same author under his newer title of Lord Avebury (Macmillan, 1902, xxvi + 534 pp., 197 figs. and pl.). The book opens with 85 pages on geology and 30 on general configuration. It then takes up such topics as coast, mountains and hills, rivers and lakes, giving to each a general consideration as well as an account of local examples, and closing with two chapters on law and names as related to topography. Many of the illustrations are half-tone plates, most of which are excellent; one of the incised meanders of the Wye is notably fine. The author disarms the critic in the preface; and indeed it is rather ungrateful to find any fault with a book that must prove useful in many ways; yet there is ground for regret that the plan of treatment adopted was not at once more thorough and more systematic. The treatment of coasts and of rivers, for example, does not do justice to the position of these important subjects in modern physiography. Truly, the items are treated in a rational and explanatory manner, but the arrangement of the items is not such as to impress the reader with their natural relations; the incised meanders of the Wye, for instance, are referred to in the section which describes normal meanders; alluvial fans of mountain torrents are described in connection with the third stage of river development in which the river, 'finally * * * reaches a stage when the inclination becomes so small,' etc. Sea cliffs are described in some detail, but the reader will not learn the relation between the ragged outline and the beachless base of young cliffs, or between the smoother outline and continuous beach of mature cliffs. The attention of geographers and philologists should be called to the new word, 'manywhere' (p. 52), of value intermediate between somewhere and everywhere.

TERMINOLOGY OF MORAINES.

An elaborate historical monograph, 'Geschichte der Moränenkunde,' by Böhm of Vienna (*Abhandl. Geogr. Gesellsch. Wien*, III., 1901, No. 4, 334 pp., 4 pl.) forms an easy means of reference to the writings of various authors on a problem that is equally shared between geologists and geographers. The earliest writers quoted are Münster (1544) and Stumpff (1548). Their successors count up to about 400, and the number of citations is 650; Agassiz, Chamberlin, Heim, Penck and Saussure are the most frequently referred to. This detailed review extends to 217 pages. Then follows a 25-page discussion of the results reached by the Glacier Conference of August, 1899, of which the author was not a member and from whose decision he dissents. The classification and terminology of moraines, as preferred by the author, are next presented in a chapter of 23 pages, closing with a table of 23 kinds of moraines named in six languages. It is notable that drumlin is the only name which holds unchanged in all countries; but moraine itself varies slightly from Italy (morena) to Norway (moræne). In this respect drumlin and moraine are imitated by atoll and monadnock. Those interested in the development of physiographic terminology may perhaps gain a useful hint from these accepted though unintentional contributions towards a universal scientific language; none of the four words are of classic origin; all come from local names of forms that have come to be used as types.

NEW NORWEGIAN MAPS.

SOME of the newer sheets of the Norwegian topographical map, 1:100,000, contain excellent illustrations of cirques, which believers in glacial erosion would ascribe to ice work. In the Reppefjelde the cirque floors stand below sea level, so that the shore line enters several curiously rounded bays, suggesting that large blocks had been bitten out of the upland. In another example the cirques have encroached so far on an upland that only a skeleton of it remains. Still other sheets exhibit the 'arm-chair' relation of cirques to the large valley upon which they open, this being a special case of the hanging valley problem. Broad trough-like valleys, with divides on their floors and lateral valleys opening on their walls, are repeatedly illustrated. These various forms are of particular interest when compared with those occurring in a well-dissected, non-glaciated mountain district, such as the old Appalachians of North Carolina, whose forms are well shown on the U. S. Geological Survey topographical sheets around Mt. Mitchell.

W. M. DAVIS.

BOTANICAL NOTES.

MORE BOOKS ON TREES.

NOTHING could show more certainly the rapidly growing interest in trees and their place in the world than the increase in the number of books on this subject. It is but a short time since two books on some phases of forestry were noticed in SCIENCE, and now it is a pleasure to call attention to three more which have appeared within a few weeks. The first is 'The Woodsman's Handbook,' prepared by Professor Graves, of the Yale Forest School, and published as Bulletin 36 of the United States Bureau of Forestry. It is a small book containing 148 pages, each 10 by 16 cm. in size, and so bound and trimmed as to be easily carried in an ordinary pocket. In it the author has attempted to bring together such information in regard to the field work of the forester as he will find necessary to have at hand for use at any moment. It is for the forester what an engineer's 'fieldbook' is to the working engineer. The scope of the little handbook may be seen from the general headings in the table of contents. Here we find 'Units of Log Measure,' 'Measurements of Sawed Lumber,' 'Measurements of Standing Trees,' 'Methods of Estimating Standing Timber,' 'Forest Working Plans,' 'Special Instruments Useful to a Woodman.' Under the first head no less than forty-five log rules are listed and described or commented upon. The author has made a most useful book, and the Bureau of Forestry is to be commended for giving it prompt publication, and especially for bringing it out in this handy form.

The next book is a 'Handbook of the Trees of New England,' by Lorin L. Dame and Henry Brooks, and published by Ginn & Company. It is a book of 196 pages, 10 by 18 cm., and bound with narrow margins for easy carrying in one's pocket. Eighty-seven species of trees are described and figured, and a few more are noticed but not illustrated. The figures are well done and must prove very helpful. The descriptions are full, and as they follow the same order in all cases, they will be useful not only to the forester, but to many a young botanist as well. Under each species the sequence of description is as follows: 'Habitat and range,' 'habit,' 'bark,' 'winter buds and leaves,' 'inflorescence,' 'fruit,' 'horticultural value,' 'explanation of the plate.' It is to be regretted that the authors followed the older nomenclature so largely, but this is not a sufficiently grave defect to seriously mar its usefulness. We wish that other parts of the country had as good books as this on their native trees.

In the 'Economics of Forestry' (Crowell & Company), by Professor Fernow, of the New York College of Forestry, we have another technical book designed for the use of forestry students. It is a work of 520 pages, 12 by 19 cm., and is bound in the usual style for the library shelf. The titles of the twelve chapters will give an idea of the scope of the work, as follows: 'The Relation of the State to Natural Resources,' 'The Forest as a Resource,' 'The Forest as a Condition,' 'Forest and Forestry Defined,' 'Factors of Forest Production and Business Aspects,' 'Natural His-

tory of the Forest,' 'Methods of Forest Crop Production, Silviculture,' 'Methods of Business Conduct, Forest Economy,' 'Principles and Methods of Forest Policy,' 'Forest Policies of Foreign Nations,' 'Forest Conditions of the United States,' 'The Forestry Movement in the United States.' There is also an appendix of valuable notes and tables. From the titles of the chapters, as well as that of the book, it is seen that it deals with the forestry problem from the standpoint of the political economist, and is in fact a contribution to one phase of this science, as well as to technical forestry. A full and satisfactory index closes this timely book, which we are sure must find its way into general use by all who are interested in the subject of forestry in any of its more general aspects.

CHARLES E. BESSEY.

UNIVERSITY OF NEBRASKA.

SCIENTIFIC NOTES AND NEWS.

THE Nobel prizes for 1902 were formally awarded on December 10. As we have already announced, the prize in chemistry was awarded to Professor Emil Fischer, of Berlin; the prize in medicine to Professor Ronald Ross, of Liverpool University, and the prize in physics was awarded divided between Professor H. A. Lorentz, of Leiden, and Professor P. Zeeman, of Amsterdam. The value of each of the prizes is about $40,000.

THE American Philosophical Society elected officers on January 2 as follows: *President,* Edgar F. Smith; *Vice-Presidents,* George F. Barker, Samuel P. Langley, William B. Scott; *Secretaries,* I. Minis Hays, Edwin G. Conklin, Arthur W. Goodspeed, Morris Jastrow, Jr.; *Treasurer,* Henry La Barre Jayne; *Curators,* Charles L. Doolittle, William P. Wilson, Albert H. Smyth; *Councilors,* George R. Morehouse, Patterson Du Bois, Ira Remsen, Isaac J. Wistar.

AT the Washington meeting of the Astronomical and Astrophysical Society of America the following officers were elected to serve for the ensuing year:

President—Simon Newcomb.
First Vice-President—George E. Hale.
Second Vice-President—William W. Campbell.
Secretary—George C. Comstock.
Treasurer—C. L. Doolittle.
Councilors—E. C. Pickering, R. S. Woodward, Ormond Stone, W. S. Eichelberger.

The time and place of the next meeting were left for subsequent decision by the council.

THE first appointments to the newly established honorary position of associate of the Harvard University Museum are as follows: Andrew Grey Weeks, Jr., of Boston, in zoology; Herbert Haviland Field, Ph.D., of Zurich, in zoology, and Robert LeMoyne Barrett, A.B., of Chicago, in geography. Mr. Weeks is a specialist in Lepidoptera; Dr. Field is the editor of the well-known *Concilium Bibliographicum;* Mr. Barrett is engaged in exploration in Central Asia.

SURGEON GENERAL WYMAN, of the Marine Hospital Service, has returned from California, where he went to investigate the alleged existence of bubonic plague in San Francisco.

THREE members of the scientific departments of Syracuse University have leave of absence for the purpose of study abroad—Dr. Charles W. Hargitt, professor of biology, sails for Naples in January, to be absent one year; Dr. T. C. Hopkins, professor of geology, will study volcanoes and glaciers in Italy, France and Switzerland, and Dr. Harold Pender proposes to repeat his experiments on electricity and magnetism at the University of Paris.

THE state commissioners of education of New South Wales, headed by Dr. G. H. Knibbs, president of the University of Sydney, have come to the United States to study our educational system.

MAJOR RONALD ROSS was given a reception by the Lord Mayor of Liverpool on December 22 in recognition of the award to him of the Nobel prize.

THE curators in the Zoological Museum of the University of Berlin, Dr. Wilhelm Weltner, Dr. Gustav Tornier and Dr. Paul Matschie have been made professors.

WE learn from *Nature* that the First Lord of the Treasury has appointed a committee to inquire and report as to the administration by

the meteorological council of the existing Parliamentary grant, and as to whether any changes in its apportionment are desirable in the interests of meteorological science, and to make any further recommendations which may occur to them, with a view to increasing the utility of that grant. The committee will consist of the Right Hon. Sir Herbert E. Maxwell Bart., M.P. (chairman), Mr. J. Dewar M.P., Sir W. de W. Abney, K.C.B., F.R.S., Sir F. Hopwood, K.C.B., Board of Trade, Sir T. H. Elliot, K.C.B., Board of Agriculture, Dr. R. T. Glazebrook, F.R.S., Mr. T. L. Heath, Treasury, and Dr. J. Larmor, F.R.S. Mr. G. L. Barstow, of the Treasury, will act as secretary to the committee.

THE Medical Society of the District of Columbia held a memorial meeting on December 31, in honor of the late Dr. Walter Reed, Major Surgeon, U.S.A. Addresses were delivered by Dr. S. S. Adams, president of the society, Medical Director Marmion, U.S.N., Surgeon J. R. Kean, U.S.A., Professor A. F. A. King, Dr. C. W. Stiles, General Leonard Wood, U.S.A., and Dr. W. H. Welch, of Johns Hopkins University.

WE recorded last week the death of Dr. Charles C. Bell, professor of chemistry in the Medical School of the University of Minnesota. Dr. Bell was born at Somerville, Mass., in 1854. He was graduated at Harvard in the class of '76, and spent several years in the study of chemistry abroad. On his return he was connected with the Johns Hopkins University and the Pennsylvania State College. He became a professor in the University of Minnesota thirteen years ago.

THE deaths are announced of Dr. John Young, lately professor of natural history at Glasgow University; of Mr. Henry Stopes, known for his researches in prehistoric archeology; of Dr. Franz Graeff, professor of mineralogy at Freiburg i. B.; of Dr. Johan Lemberg, professor of mineralogy and geology in the University at Dorpat, of Dr. T. Zaaijer, professor of anatomy and embryology in the University of Leiden; and of Dr. Antonio d'Achiardi, professor of mineralogy and geology at the University of Pisa.

A COMPETITIVE examination of the New York Civil Service Commission will be held on January 24 for the position of structural engineer in the State Architect's Office at a salary of $2,000. The duties include calculation of strength and stability of structures, including floors, girders, roofs, columns, walls, piers and foundations, design of roof trusses, inspection of foundation soils, design of water supply systems, and require a knowledge of retaining walls, calculation of quantities, modern steel and concrete construction and road building. Subjects of examination and relative weights: Theoretical and practical questions, 6; experience and education, 2.

MR. ANDREW CARNEGIE has offered to give the city of Philadelphia $1,500,000 for the erection of thirty branch libraries, on the condition that the city provide the sites and $5,000 a year for maintenance for each branch. Mr. Carnegie has also offered to give $100,000 to Camden for a library building.

MR. HENRY PHIPPS, of New York City, has given $300,000 for the establishment in Philadelphia of 'The Henry Phipps Institute for the Study, Treatment and Prevention of Tuberculosis.'

DR. WILLIAM B. GRAVES, of East Orange, N. J., has presented a well-equipped bacteriological and pathological laboratory to the Orange Memorial Hospital, to be known as the Graves Laboratory.

A PRESS dispatch from Cambridge states that notice has been received at the Harvard Astronomical Observatory of a gift of $2,500 from the Carnegie Institution. The award is for the year 1903 and the money is to be used toward paying the salaries of experts who are to study the large collection of astronomical photographs which have been made by the observatory.

MR. ANDREW CARNEGIE has signalized his acceptance of the vice-presidency of the Iron and Steel Institute of Great Britain by establishing seven student scholarships of an annual value of $500 each for the furtherance of metallurgical research.

THE London *Times* states that the Swedish Antarctic exploration ship *Antarctic* left Tierra del Fuego at the beginning of November on its second summer expedition. It was expected that the expedition, after some cartographic work and natural history research in the northern and western portions of the Dirck Gerritz Archipelago, would arrive about December 10 at the winter quarters in Snow Hill Land, where Dr. Nordenskjöld would resume the leadership of the entire expedition. The *Antarctic* will probably return to Port Stanley (Falkland Islands) at the end of February or the beginning of March.

UNIVERSITY AND EDUCATIONAL NEWS.

DR. D. K. PEARSONS, of Chicago, has made a gift of $50,000 to the endowment fund of Pomona College at Claremont, Cal.

GENERAL O. O. HOWARD, president of the board of directors of the Lincoln Memorial University at Cumberland Gap, Tenn., announces that the $200,000 which they desired for the endowment of the school has been raised.

DR. GUSTAV A. ANDREEN, president of Augustana College, at Rock Island, Ill., has sailed for Sweden, where he goes to accept a $29,000 gift from Swedish educators and business men to Augustana College.

A FELLOWSHIP of the value of four hundred and fifty dollars has been established by the trustees of Smith College for the encouragement of advanced work in philosophy and psychology. It is open to women graduates of not less than one year's standing of Smith and of other colleges, and is awarded annually, subject to renewal at discretion, to the candidate judged best fitted to profit by it. The holder of the fellowship is required to render a certain amount of assistance (not instruction) in the philosophical department, but is free, and is expected, to devote most of her time to some specified line of work under the direction of the instructors and to present a thesis, embodying the results of her studies, at the end of the year. The work so done may be taken to qualify her for an advanced academic degree. Application for this fellowship should be sent, with testimonials and other vouchers, to Mr. H. N. Gardiner, Smith College, Northampton, Mass., by May 1.

AT the Ohio State University a veterinary building costing $35,000 and an addition to the chemical building costing $22,000 are now being constructed. Besides these, a building costing $80,000 for the department of civil engineering and drawing will be commenced as soon as the weather will permit, and plans have been ordered for a physics building costing from $80,000 to $90,000. The funds for these structures have all been provided. Each of the buildings will be planned with reference to future additions. The enrolment of the institution during the past term was 1607, a gain of nearly 200 over the corresponding time one year ago.

A NEW four-story building, 186 x 70 feet, for the departments of mechanical engineering, mining engineering and geology at Lehigh University is in process of construction.

THE trustees of Columbia University have voted to designate the physical laboratories for research the Phœnix Physical Laboratories, in memory of Stephen Whitney Phœnix, of the class of '59, who left a large bequest to Columbia.

DR. J. J. THOMSON, F.R.S., for the past eighteen years Cavendish professor of experimental physics at Cambridge University, has been offered by the trustees of Columbia University the chair of physics, vacant by the death of Ogden N. Rood. Professor Thomson was born at Manchester in 1856, and attended Owens College and Trinity College, Cambridge. At Cambridge he was second wrangler and second Smith's prizeman in 1880 and was elected fellow of Trinity College in 1881. In 1884 he succeeded Lord Rayleigh as professor of experimental physics.

DR. CHARLES L. POOR, formerly associate professor of astronomy at the Johns Hopkins University, has been appointed lecturer in astronomy in Columbia University.

THE general board of studies of Cambridge University has appointed Mr. F. G. Hopkins, M.A., of Emmanuel College, to the office of reader in chemical physiology.